THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 33 MARCH, 1935 No. 3

THE PHYSICAL DETERMINATION OF RADIUM DOSAGES*

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IN 1901, H. Becquerel, the discoverer of radioactivity, accidentally produced on himself a skin reaction similar to a sunburn after carrying a radium preparation in his vest pocket for some time. At about the same time Pierre Curie produced a similar reaction intentionally by exposing part of his arm to radium for several hours. Both Pierre and Marie Curie followed these observations by numerous experiments on animals, and they may well be called the founders of radium therapy or curie therapy, as it should be called.

Soon after these original experiments the question arose as to how the dosages of radiation applied from these radioactive substances should be measured. A similar problem presented itself at that time in the application of roentgen rays for therapeutic purposes. Radium had one advantage over the roentgen rays in this respect. The radium preparation was constant over a long period, while the output of roentgen rays from the tubes used at that time varied widely and also was constantly fluctuating. The further development of dosage methods for roentgen and curie therapy has led to the adoption internationally of the roentgen for roentgen therapy, but the problem of a similar definite unit for radium dosage has not yet been solved satisfactorily. The reasons for this will be listed briefly in this paper and are to be illustrated somewhat more in detail in the subsequent papers in this symposium.

After several radium preparations were successfully compared by the gamma-ray method following suggestions made at the Congress of Radiology and Electricity in Brussels in 1910, the preparation of 21.99 milligrams of pure radium chloride made by Madame Curie was accepted as the international standard. From then on, dosages in radium therapy were frequently stated in milligrams of radium element used and the duration of treatment which later gave rise to the term "milligram-element-hours." Subsequently, the distance of the radium source from the point to be irradiated and the type of filtration used were stated. The specification of radium dosage in "milligram-element-hours per centimeter" is still widely employed. Sievert[1] recently redefined this unit, adding the provision that the radium source be completely surrounded by a filter of 0.5 mm. of platinum, and also that it be small enough to be considered a point source. Other dosage units have been suggested during the last twenty years. The calculation of "millicuries-destroyed" was proposed by Debierne and Regaud in 1914 and is in general use in France. Other units suggested were the "radio," the "rad," the "eve," and sev-

* Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

eral biological units, but none of these has been accepted by any large group of workers.

The interest in the "eve" has recently been renewed. In a series of papers published in the *Philosophical Magazine* from 1906 to 1914, Eve[2] determined the number of ion pairs which are produced per second by gamma rays from 1 curie of radium C at a distance of 1 centimeter in 1 cubic centimeter of free air. He and other workers arrived at a constant which subsequently became known as Eve's constant. This amounts to 4.26×10^9 ion pairs at 0° C. and 760 mm. pressure. From this figure the number of ions per milligram hour can be calculated and this can again be converted easily into electrostatic units. By such calculation the figure arrived at is 7.35 electrostatic units for the conditions enumerated above. Since 1 electrostatic unit per cubic centimeter under these conditions corresponds exactly to 1 roentgen, by this calculation, the result obtained is that 1 milligram-element-hour at a distance of 1 centimeter corresponds to 7.35 roentgens.

This is especially interesting to us because about six years ago when we first introduced our condenser dosimeter and proposed a method for determining radium dosages in roentgen units by means of small air wall chambers we obtained a similar figure.[3] In 1928 we presented our data at the Second International Congress of Radiology and in 1929 we published several papers on the subject in which we obtained the relation 1 milligram-element-hour per centimeter equals 7.4* roentgens, which is in close agreement with the value obtained from Eve's constant. Recently, Jaeger[4] of the German Bureau of Standards, who first called attention to this interesting relation, and Mayneord and Roberts[5] at the London Cancer Hospital have also investigated this problem and have obtained approximately the same result. Hence it would appear that our original suggestion that the roentgen unit should also be used in radium therapy, a suggestion which has been attacked from several quarters, is feasible and should find wider support. Naturally the milligram-element-hour per centimeter is not a well-defined dosage unit and for this reason the relation between it and the roentgen will only hold true if the conditions of the experiment are known and taken into account. In addition, all the factors which play a rôle must be specified for each treatment condition. These factors have been enumerated by Quimby and Failla[6] as follows: strength of the radioactive source, the distribution of the radioactive source, the filtration, distance or spacing, the duration of irradiation, the location of the tumor, the size of the tumor and the depth of the tumor.

With an adequate measuring device, such as a condenser dosimeter equipped with a small ionization chamber (of about 1/40 c.c. volume) the first four of these factors can be satisfactorily measured, just as similar dosages of roentgen rays are determined under different conditions of treatment. Naturally such factors can also be calculated separately. The last three factors listed have to be determined separately in each case and their influence upon the dosage must be determined by experience. When measurements are made with a small ionization chamber, errors in calculations involving filter material and thickness, the distribution of the radioactive substance within the capsule and the distance are eliminated, because the measurement represents the intensity which actually exists at a certain point.

Nevertheless, this advantage does not exclude the necessity for a certain standard technique in the administration of radium irradiation, and the American Radium Society and especially its Committee on Research and Standardization should continue its good work toward standardizing the size, shape and content of radium preparations, filters, etc. At the present time there is little or no uniformity in these matters and a casual glance into the literature re-

* This roentgen is not corrected for temperature and pressure. A redetermination of the equivalent value, to be published soon, is 8.4.

veals the wide discrepancy in filters and in the size and shape of radium preparations used by various radiologists. Some suggestions for uniformity in radium applicators are to be presented at this meeting and any possible advance in this respect should be greeted with enthusiasm.

The following papers in this symposium will show how the physical factors enumerated here concern the problems of teleradium therapy, and interstitial and intracavitary dosage of radium, and also how they may be correlated with biological and clinical methods.

CONCLUSIONS

1. No satisfactory dosage unit for curie therapy similar to the "roentgen" in roentgen therapy has been generally accepted.

2. A calculation of radiation intensity at 1 centimeter distance from 1 gram radium element per hour by means of Eve's constant gives 7.35 roentgens.

3. This same value for identical conditions was obtained by us a number of years ago by means of the condenser dosimeter and a small (1/40 c.c.) air wall chamber, and has recently been confirmed by Mayneord and Jaeger.*

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* For discussion see page 337.

PHYSICAL FACTORS IN TELERADIUM THERAPY*

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THE effect of the treatments by means of teleradium is determined by both physical and biological factors. The physical factors determine the relative distribution of the radiation in the tissues and the total amount absorbed at different points. The distribution of the radiation with respect to time is a biological rather than a physical problem and will therefore not be considered in detail.

It is evident that the relative distribution of the radiation and the total amount of radiation absorbed at different points have a deciding influence on what results are obtained and it is important that we know which factors influence these conditions and how they affect them. The main factors are: the radium-skin distance, the filters used, the distribution of the radium, the secondary radiation from parts of the applicator and the change the radiation undergoes in passing through the tissues.

1. *Filters.* Teleradium is used for tumors located at some distance under the skin and the idea is to obtain a good depth dose. It is therefore important to eliminate the β-rays and the soft γ-rays which would be almost completely absorbed by tissues between the surface and the tumor. Fortunately this can be done quite satisfactorily without a great loss of penetrating rays. Failla has shown that 2 mm. of brass removes practically all the soft rays and that it is advisable to use 2 mm. of pure rubber under the brass to stop secondary rays from the metal. Two millimeters of brass stops about 100 per cent of the β-rays, 50 per cent of the soft γ-rays and 8 per cent of the hard γ-rays; 1.5 mm. of lead accomplishes about the same result. An additional thickness of 1.5 mm. of lead or 2 mm. of brass reduces the intensity of the radiation by about 10 per cent without increasing the penetrability in regard to the tissues a great deal. The time required to give the same dose (and therefore the expense) thus is increased 10 per cent by this additional filter. It seems wasteful to use so much filter unless the slight increase in the hardness of the rays really makes them more specific in their action on cancer tissue or less destructive to the skin, a problem which will not be considered in this discussion. Further addition of filter increases the time and expense in about the same proportion or nearly 10 per cent per 1.5 mm. of lead. The amount of radiation absorbed by 1 cm. of tissue after the rays have passed through 2 mm. of brass and 2 mm. of rubber may be considered as about 5 per cent. The next centimeter absorbs 5 per cent of the 95 per cent left, leaving 90.3 per cent, and so on. Thus 10 cm. absorbs 40 per cent of the total.

2. *Distance.* In discussing the effect of distance from radium to skin on the depth dose it is advisable to consider at first a point source, assuming that all the radium is concentrated in one very small container with adequate filter to remove β-rays and soft γ-rays. The time required and thus the expense entailed in applying a certain dose to the skin increases in proportion to the square of the distance between the radium and the skin. This is due simply to the fact that the rays are spreading out in all directions from the source. The next step is to consider the effect of this spreading on the intensity at depth without considering the loss of radiation due to absorption and scattering.

In the following calculations, B refers to the intensity of the primary radiation at the skin and b cm. to the distance from the source to the skin. The intensity is inversely proportional to the square of the distance. Therefore the intensity at a point b cm. directly under the skin would be equal

* Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

to $b^2/(2b)^2 \times B$ or equal to 0.25 B. At 2 b cm. under the skin the corresponding intensity would be $b^2/(3b)^2 \times B = 0.11$ B and at 3 b cm. equal to $b^2/(4b)^2 \times B = 0.0625$ B. This is illustrated by Fig. 1, I. As a next step, assume the skin removed to the distance 2 b cm. from the source. To obtain the same intensity as before at the skin it is then necessary to make the source 4 times as strong. At the same time the intensity at the distances 3 and 4 b cm. away from the source will be 4 times what they were. Therefore 1 b cm. under the skin the intensity would be 4×0.11 B or 0.44 B and 2 b cm. under the skin 0.25 B (see Fig. 1, II). The intensity 1 b cm. under the skin is nearly doubled and the intensity 2 b cm. under the skin more than doubled when the distance source to skin is increased from b cm. to 2 b cm. If only 0.11 B were needed at 2 cm. depth it would be twice as expensive to use the greater distance, 2 b, but the upper layer of the tissues would then receive much less radiation and consequently be less damaged.

It was mentioned before that 1 cm. of tissue absorbs about 5 per cent of the radiation. If 1 cm. radium-skin distance is used instead of 2 cm. (with four times as much radium) 44 per cent of the intensity at 1 cm. depth is lost due to the spreading of the rays and this shows that the distance has the greatest influence on the depth dose. Even if b = 10 cm. the absorption in 10 cm. of tissue is only 40 per cent, whereas the depth intensity is reduced 44 per cent by the use of 10 cm. radium-skin distance instead of 20 cm. By using 30 cm. source-skin distance the loss due to absorption and due to spreading would be nearly the same. In treating a tumor it therefore seems almost useless to try and reach as great a distance under the skin as the radium is placed above the skin. It should also be noted that by reducing the 20 cm. source-skin distance to one-half, the loss at 1 cm. depth due to the spreading is still 8 per cent, or more than from absorption. An appreciable improvement in depth dose can be obtained by increasing the distance but not by increasing the filter. Unfortunately the expense in using radium at 20 cm. distance or more is, as a rule, prohibitive.

3. *Distribution of Radium in Applicator.* It is seldom that radium is used in such a way that it can be considered a point source. Usually the radium is spread over a considerable surface and this is a more eco-

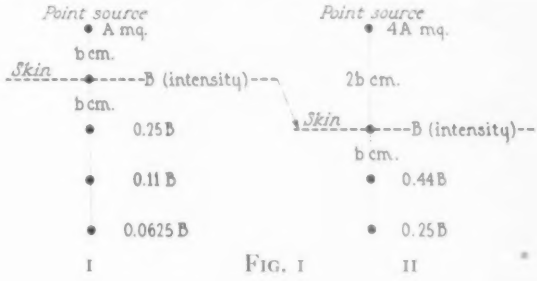

FIG. 1

nomical way of utilizing it. From a mathematical point of view it is simplest to consider the radium spread at the periphery of a circle. This could be accomplished by having the radium sealed in a long metal tubing bent together to form a ring. The diameter of this ring is here called 2 d. No corrections will be made for the fact that the rays strike the skin under angles smaller than 90° because the cosine law of irradiation is not applicable to penetrating rays. If the circle or ring is at a distance b from the skin the intensity at the center of the field on the skin is the same as if a point source were used at a distance equal to $\sqrt{b^2+d^2}$ or at the distance $b\sqrt{2}$ if b = d. It can be shown mathematically that the surface intensity is highest at the center of the field as long as d is equal to or less than b whereas it reaches a maximum at some distance from the center along a circle if d is larger than b. The dose at depth depends upon how well the surface is utilized and is, as a rule, greatest when the distribution over the exposed surface is uniform. With a field of the diameter 2 b the intensity at the periphery of the field figures out to be 90 per cent of the intensity at the center for the ring source (diameter 2 b and distance b). For a point source at distance $b\sqrt{2}$ the intensity at the periphery is only 67 per cent of the intensity at the center. It is evident

that if the radium is spread on a surface, inside the diameter 2 b on the sphere that passes through the point source at distance $b\sqrt{2}$ and the ring source at distance b, intermediary values would be obtained. It is therefore most economical to use such a ring source and when a radium pack is used it is as a rule best to have the radium placed peripherally inside the pack. Table 1 shows the intensity at the surface and at the depths b/2, b, $b\sqrt{2}$, 2 b and 3 b, when the absorption and scattering are neglected. It also shows in columns 6 and 7 the gain at depth of a ring source over a point source both at center and at the periphery of the field. The gain in the depth dose at the center may not be quite as great as shown in the table because the rays have to travel a longer distance through tissues and are therefore absorbed to a greater extent. The increase of scattered radiation from the surrounding tissues offsets this loss to a certain extent. For b equal to 10 cm. the rays have to pass through 1.12 cm. additional tissues to reach the center at depth b and thus a maximum loss of 5 per cent of the depth dose would result. Another thing which has to be considered is the difference in filtration of rays going in different directions. If the main filter surrounds the radium tubes this effect is negligible but when the filter is placed as sheets under the radium the effect becomes more important the heavier the filter. Thus if the filter is 3 mm. of lead for the rays passing through at a right angle, it is 4.3 mm. for rays passing through at a 45° angle and 6 mm. at a 30° angle. This means an appreciable reduction in intensity. Due to these and other complicating factors, it is evident that definite values of the dose can be obtained only by exact measurements.

4. *Secondary Radiation.* The secondary radiation from parts of the applicator increases mainly the surface dose, particularly at the periphery of the field. Rubber or other organic material between the metal and the skin reduces this radiation. What is left is included in the measurements.

5. *Scattering.* A considerable amount of radiation is scattered by the tissues. The rays are softened during this process and part of the energy is absorbed. As more rays are scattered in the forward direction than backwards the maximum amount of absorption is apt to take place at a certain depth decreasing as well towards greater depth as in the superficial layer above. The dose at any one point is therefore not determined exclusively by the intensity of the primary radiation. It is for this reason that the intensity has been referred to instead of the dose in most instances in the previous discussion.

Table I

Relative intensities I at different depths as a consequence of the spreading of the rays (absorption neglected), calculated for a point source at a skin distance = $b\sqrt{2}$ and a ring source of diameter 2 b at a skin distance b, when the same amount of radium is used in both instances.

Depth	Point S. Dist. $b\sqrt{2}$. I at center	I at periphery	Ring S. Dist. b. Diam. 2 b. I at center	I at periphery	Increase Ring-Point S. center	periphery
0	100.0%	66.7%	100.0%	89.4%	0%	34%
½ b	54.7		61.5		13	
b	34.5	29.4	40.0	35.4	16	20
$\sqrt{2}$ b	25.0		29.4		17	
2 b	17.2	15.8	20.0	18.5	16	17
3 b	10.3		11.8		15	

Skin Erythema Dose. If a filter of 2 mm. of brass and 2 mm. of rubber is used 160 mg-hr. may be considered as the amount required to produce a threshold erythema when a point source is used at 1 cm. distance. If in each instance a suitable amount of radium is used so that the full dose is obtained in some few hours, the number of

milligram-hours required for a point source at other distances in order to obtain the same skin reaction can be calculated by multiplying 160 by the square of the distance measured in centimeters. The results of such calculations are given in Table II.

Table II

MILLIGRAM-HOURS REQUIRED FOR A THRESHOLD ERYTHEMA DOSE FROM A POINT SOURCE. FILTER 2 MM. BRASS PLUS 2 MM. RUBBER. SUITABLE AMOUNT OF RADIUM TO GIVE THE FULL DOSE IN SOME FEW HOURS ASSUMED.

Distance	1	2	4	6	8	10	14	20 cm.
Mg-hr.	160	640	2,560	5,760	10,240	16,000	31,360	64,000

If a ring source is used the number of milligram-hours required for the same dose can be calculated with reasonable accuracy simply by adding the figures in Table III to the values for the same distance given in Table II. This addition depends only upon the diameter of the ring and is independent of the distance. The dose is simply equal to $160\,(b^2+d^2)$ mg-hr. For example, for a ring source of 10 cm. diameter used at 10 cm. skin distance the dose would be (16,000 + 4,000) mg-hr. = 20,000 mg-hr. Approximately the same amount should be used if the 2 mm. brass filter is replaced by 1.5 mm. of lead. The correction of additional lead filter is 7 per cent for each millimeter when the lead surrounds the radium. If it is placed as a sheet under the radium the calculation is more complicated. For dimensions b = d it would be 10 per cent for 1 mm. lead.

Table III

MILLIGRAM-HOURS TO BE ADDED TO THE POINT SOURCE VALUES IN ORDER TO OBTAIN A THRESHOLD ERYTHEMA DOSE FOR A RING SOURCE

Diameter of ring	1	2	4	6	8	10	14	20 cm.
Mg-hr.	40	160	640	1,440	2,560	4,000	7,840	16,000

A Small Model. The features referred to as ideal have been incorporated in the little model shown in Figure 2. The inside diameter is 2 cm. and the distance source to skin 1 cm. A gold tubing with 0.3 mm. wall and 6.3 cm. length has been filled with radon. This is the type of tubing used for ordinary implants. It has been bent into a ring which just fits in the container on top of the additional filter of 1.5 mm. brass.

A small segment of fiber has been placed on top of the brass filter and it has such a shape that a smaller gold ring or a bulb would be placed at the proper distance from the skin to deliver the same dose in the center of the field with the same amount of radiation (mg-hr.).

Experimental. In order to get an idea of how the radiation is distributed at the surface and at 1 and 2 cm. depth, photographic films, enclosed in black paper, have been exposed at these three levels. One millimeter rubber was used under the pack and a block of paraffin 4 cm. thick was used under the films. Blocks of paraffin 1 and 2 cm. thick were placed between the pack and the films to obtain the distribution at these depths. The exposure for the surface film had to be varied until a suitable density was obtained. Then a set of films was exposed using the number of millicurie-seconds found correct for the surface and 4 and 9 times this amount for the 1 and 2 cm. depth respectively. These films were developed together. Photometric curves were made for all the films in order to demonstrate the intensity distribution more clearly. Finally graphs were made from these curves after the intensity for those corresponding to the films exposed at 1 and 2 cm. depth had been divided by 4 and 9 respectively (Figs. 3 and 4). These graphs cannot be expected to give the true values of the

Radon Pack

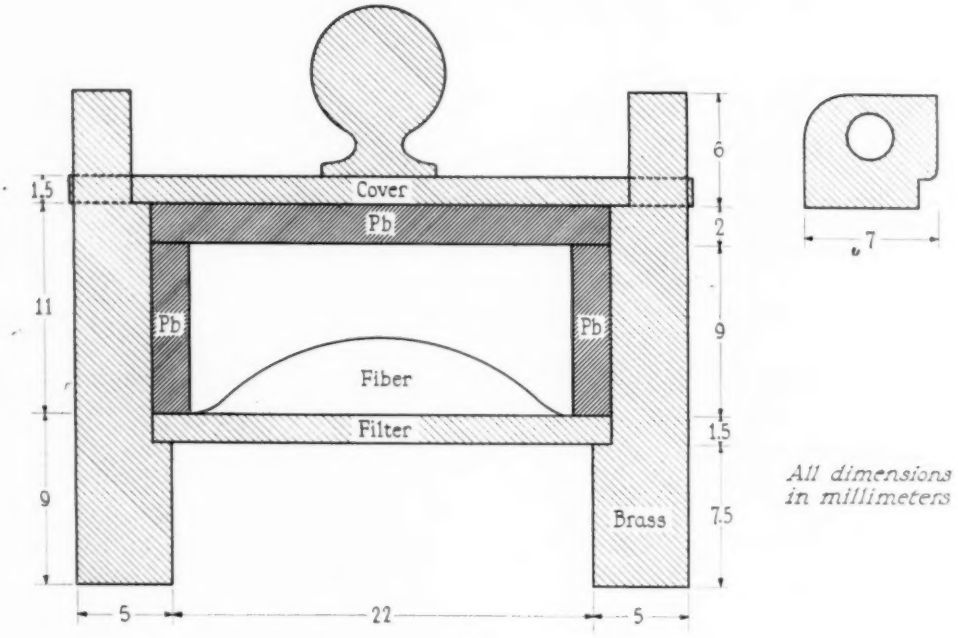

FIG. 2

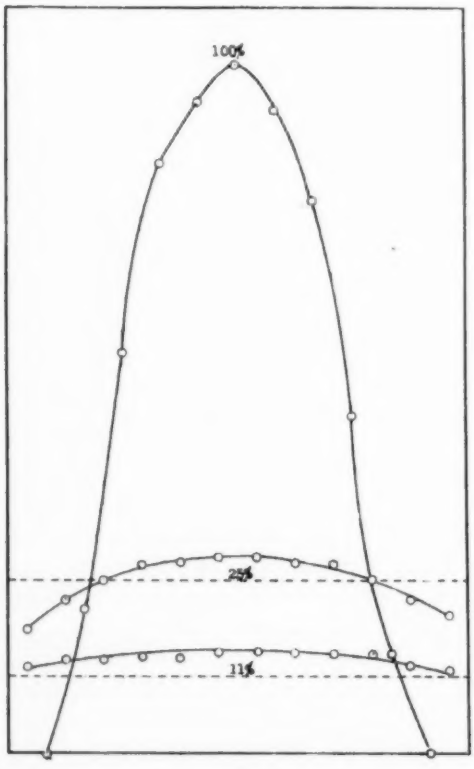

FIG. 3. Relative density of films exposed at surface and at 1 and 2 cm. depth. Bulb source.

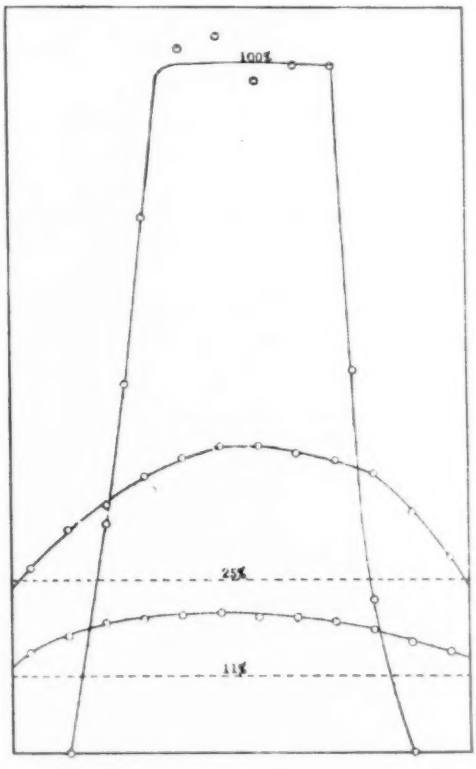

FIG. 4. Relative density of films exposed at surface and at 1 and 2 cm. depth. Ring source.

depth doses but they at least indicate: (1) that the surface dose is quite even over the field and falls off rapidly at the wall of the pack when the ring source is used, while it falls off rapidly from the center to the periphery for the point source; (2) that the dose at a certain depth reaches a maximum in the center of the field and falls off very gradually, still being considerable at a distance 3 d from the center; (3) that the depth dose is higher than the corresponding intensity of the direct radiation; (4) that the depth dose for the ring source is greater than for the point source.

It seems that the principles outlined could be applied for the construction of large packs or bombs. It should not be very difficult to arrange the radium in a ring. The bomb can be made so that the radium may be moved to any desired distance. It can be built in a symmetrical manner so that the rays may be utilized at both ends, making it possible to treat two patients simultaneously. A square field may be obtained by adding a lead applicator with a square aperture at the lower end, gradually widening out to a circle of diameter 2 d at the upper end.

It is difficult to obtain accurate measurements with such a small pack as the model referred to. It also seems quite useless to attempt it as the distribution could not be applied to other packs. Measurements would have to be made for each bomb of considerably different dimensions.*

* For discussion see page 337.

I am obliged to Dr. Carl Nurnberger, who carried out most of this experimental work.

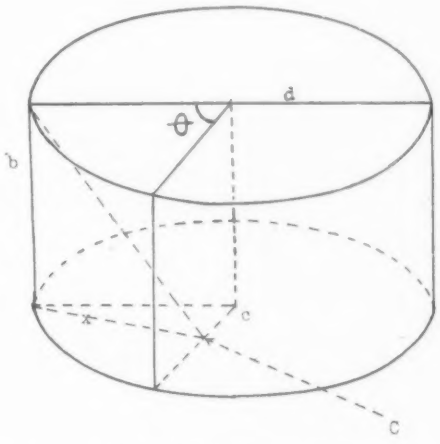

FIG. 5. x, b, d and c distances in cm. C an arbitrary point of the lower surface at distance c from center. Intensity at one cm. distance from a point source = 1. Intensity at $C = I$.

From Fig. 5 is obtained

$$x^2 = c^2 + d^2 - 2dc\cos\theta$$

$$I = \frac{1}{2\pi}\int_0^{2\pi} \frac{d\theta}{b^2 + d^2 + c^2 - 2dc\cos\theta}$$

$$I = \frac{1}{\sqrt{(b^2 + d^2 + c^2)^2 - 4d^2c^2}}.$$

Maximum $I\left(\frac{dI}{dc} = 0\right)$ when $2c(b^2 + d^2 + c^2) - 4d^2c = 0$

or $b^2 + c^2 = d^2$.

Therefore max I at center ($c = 0$) when $d \leqq b$.

If $d > b$ max intensity at a circle of radius $\sqrt{d^2 - b^2}$.

At center $c = 0$ $I = \frac{1}{b^2 + d^2}$.

At periphery $c = d$ $I = \frac{1}{b\sqrt{b^2 + 4d^2}}$.

PHYSICAL FACTORS IN INTRACAVITY RADIUM THERAPY*

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IN ORDER to derive the greatest benefit of intracavity irradiation, skill is essential in choosing the number and arrangement of radium capsules. The ultimate aim is to obtain as nearly as possible equal distribution of intensities throughout the irradiated area, and to deliver as large a quantity of radiation as the tissue will tolerate.

A review of the literature impresses one as to the variation in techniques used in irradiation of intracavity lesions. Definite stereotyped techniques will probably not be adhered to routinely for each and every case, because experienced radiologists believe that patients should be more or less individualized.

There are, however, fundamental physical factors governing radium irradiation which apply to all techniques, such as (1) distance, (2) filter, (3) size and shape of applicator and (4) penetration.

If an applicator had all the radium concentrated at a point, it would be comparatively simple to determine the distribution of radiation, since in air the intensity varies inversely as the square of the distance from a point source, and it would be possible to compute the distribution of radiation knowing the tissue absorption value, but the usual radium or radon source of radiation is of considerable size and contains many point sources. The resultant radiation intensities from these multiple point sources produce an unequal distribution of radiation about a capsule which is usually cylindrical. The greatest intensity is produced underneath the center of the capsule as shown in Figure 1 by Glasser.[5] This means that if the dose of radium radiation is determined for the most intense section of the capsule, the dose for the ends will be considerably less. This fact should always be present in the mind of the radiologist when placing radium capsules in position.

Even though there is not a uniform distribution of radiation about a radium capsule, a more uniform distribution of radiation can sometimes be attained by carefully placing the capsules about the lesion —as shown by Widmann[11] and myself.[10]

As the distance between the radium applicator and the surface of the lesion increases, the number of millicurie- or milligram-hours, or millicuries-destroyed must also increase if comparable surface doses are maintained. Even though the shape and size of applicators vary and the source of radiation cannot be considered at a point, one should strive to have dosage tables indicating the variation in intensities. Also the radiologist ought to appreciate that small changes of distance amounting to 1 or 2 mm. are significant and should be taken into consideration.

The question as to the proper filtration has been the subject of much thought and experimentation. Failla[3,4] and Quimby[8] in 1920 to 1921 made measurements of radium radiation passing through 0.48 mm. to 3.04 mm. of lead and 0.48 to 3.04 mm. of brass. It was shown in this experiment that 2 mm. of brass was sufficient filtration to remove practically all the beta radiation.

During the last few years there has been a gradual increase in filtration. Some radiologists are using 1.0 and 2.0 mm. platinum or equivalent filtration in lead. Is there any physical basis for the increased filtration? Quimby and Marinelli[9] have shown that in roentgen rays the average wave length increases as the radiation penetrates into the tissue due to the Compton effect.[2] Therefore, if the average wave length of the source of radiation is reduced by increased

* From the Radiological Department of the Philadelphia General Hospital. Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

filtration, then the average wave length of radiation penetrating into the tissue will still be of a shorter wave length than radiation filtered by 2 mm. brass. The shorter wave length radiation will scatter to a greater extent in the general direction of the beam of radiation. This will result in an increased tissue dose, and a probable reduction in the intensity produced by back-scattering to the surface. Leucutia and Corrigan[7] have shown in super-high voltage roentgen rays that there is less back-scattering to the surface as the wave length is reduced. The ratio, therefore, between the surface dose and the dose in the tissue will be increased due to a reduced average wave length radiation striking the surface of the lesion and a general increase in scattered radiation in the direction of the beam.

Penetration into the tissue with intracavity irradiation may be increased (1) by an increase in the distance between the applicator and the lesion, (2) by increasing the filtration whereby there is increased scattered radiation in the tissue and a small reduction of back-scattering to the surface, (3) by decreased absorption of radiation in the surface of the tissue as the wave length decreases, as shown by Lauritsen.[6] Therefore, if the average wave length is decreased by increased filtration, many radiologists clinically are of the opinion that they can give a greater quantity of radiation with equal tissue reaction to the surface of the lesion with a correspondingly greater depth dose.

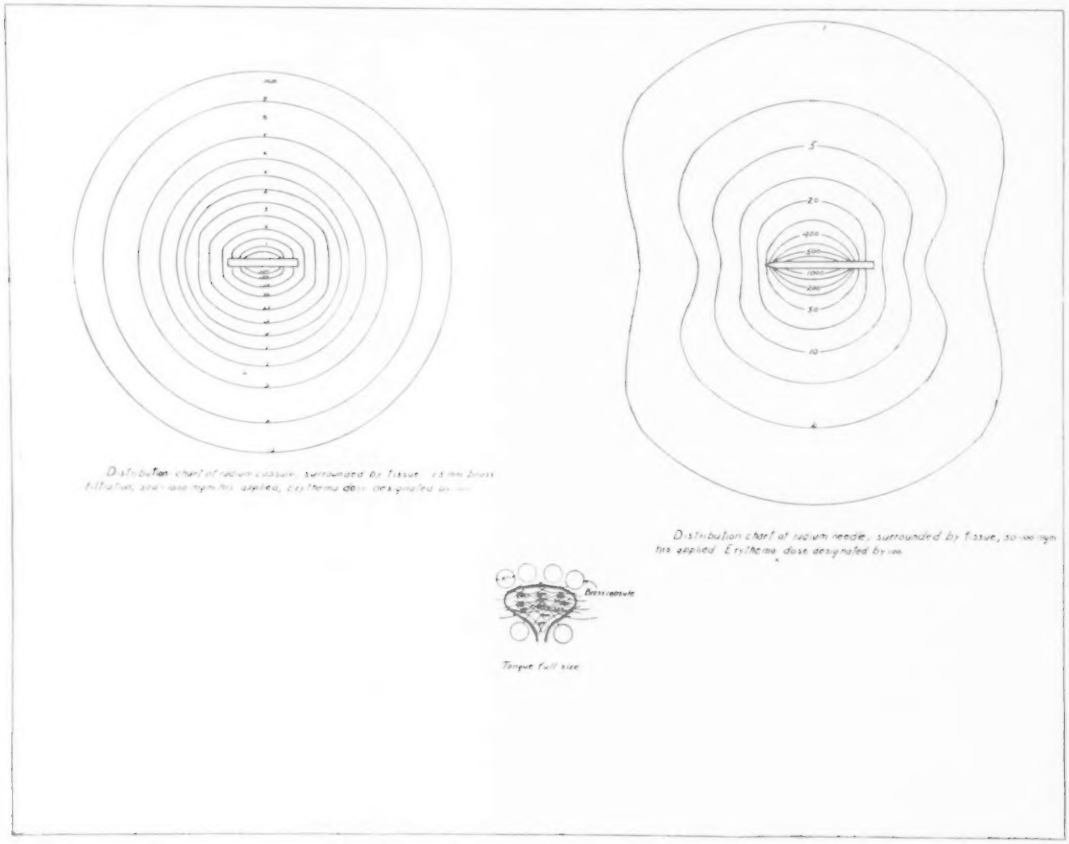

FIG. 1

If Figure 1 approximately represents the distribution of radiation about a capsule of radium or radon, one can consider a zone of irradiated tissue throughout which there is delivered a lethal dose, providing the total dose from the capsule is adequate. There is

another imaginary zone about the capsule or capsules which can be considered as having a sublethal dose, etc. Is it possible to extend the sublethal and sub-sublethal zones into lethal zones by arranging radium treatments with roentgen treatments so that the radium and roentgen-ray tissue reactions occur together? Behney[1] has shown better end-results in the treatment of advanced carcinoma of the cervix by a combination of radium and roentgen irradiation. If roentgen treatment is combined with radium treatment in order to obtain the reactions together, how much roentgen irradiation should be given along with adequate radium irradiation? It is true that definite standard doses of roentgen radiation probably should not be given to every patient regardless of the type of lesion and physical condition of the patient. Even though patients should be individualized as to types of lesions and physical condition, there is no reason why the radiologist should not have average standardized doses of radium alone, radium along with roentgen irradiation, total quantity, and duration of treatment or treatments, as well as the number of series. If a divided dose technique is employed, what should be the rate, duration of treatment and total quantity of radiation? Should a divided dose technique be used for roentgen radiation such as the "saturation technique" for abdominal lesions and Coutard's method for other lesions? Carefully evaluated clinical statistics will be of great help in attempting to solve some of these problems.

The physicist can help the radium therapist to approach dosage standardization for different lesions, but in the end it becomes a clinical problem in how to employ standardized doses of radium irradiation in treating individual patients.

Unless there is a proved wave length affinity for malignant tissue, the treatment of patients becomes a problem of delivering as much radiation as possible to the tumor area and still keep the patient in good physical condition. In order to accomplish this, it will be advantageous for the radium therapist to cooperate to the fullest extent with the roentgen therapist.

CONCLUSIONS

1. The radiologist should plan intracavity treatment of a lesion keeping in mind the following factors: (1) location of lesion; (2) distance of applicator from the surface of the lesion; (3) filter employed; (4) size and shape of applicator; (5) penetration.

2. Experience has demonstrated that in the treatment of many intracavity lesions, it is impossible to deliver a lethal dose throughout the entire lesion with radium alone.

3. The lethal zone produced by radium can be extended by combining roentgen irradiation and it would seem advisable to have the height of tissue reaction for both radium and roentgen irradiation occur at approximately the same time.

4. Assuming that radiologists have experience in the proper evaluation of the factors pertaining to intracavity irradiation, the greatest advances in the future will be made by obtaining both clinical and experimental evidence in coordinating intracavity and roentgen or teleradium irradiation.*

* For discussion see page 337.

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PHYSICAL FACTORS IN INTERSTITIAL RADIUM THERAPY*

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FOR the adequate treatment of malignant disease by means of radiation, it is essential to know the quantity of radiation delivered to the tumor mass, and to the tissues in its immediate neighborhood. Because of the physical characteristics of radiation, it is, in general, impossible to irradiate a given mass homogeneously. If it is true that in order to produce complete regression in any specific type of neoplasm it is necessary for every cell to receive at least a certain dose of radiation, then it is the minimum quantity delivered to any point in the affected region which should be known.

The physical factors of radium dosage are the same for both external and interstitial sources, namely, length, strength, and filtration of the individual sources, their grouping, and their distance from the tissue cells it is desired to affect. The duration of irradiation, the so-called "time factor," while not, strictly speaking, a physical factor, should also be considered.

There are at present no adequate means for actually measuring the radiation within the tissues; in order to obtain values which are approximately correct it is necessary to resort to various tissue substitutes which permit of the necessary manipulations. For external sources, the well-known method of water phantom and small ionization chamber has given a great deal of useful data. For interstitial sources, however, such methods are of little value. The variation in intensity in the tissue with variation in distance from the source is enormous, within the radius of effective action of the usual implant. The size of the ionization chamber is large in comparison with the distances under considera- and measurements of ionization in such a case have little meaning. It is therefore necessary to find other methods of approach to the question.

Several aspects of the problem must be considered. In the first place, it is necessary to establish a unit of radiation dosage. The distances within the tissues at which a given implant will deliver a specified dose in a given time must be investigated. The variation in dose with distance from a specified implant is important, as are the differences in dosage which result when any of the physical characteristics of the implant are altered, as length, filter, strength. When several implants (seeds or needles) are to be used in a given mass, the radiation delivered at any specific point is a summation of doses from the separate sources, and the effect of arrangement and spacing must be considered.

The author, in collaboration with several members of the Memorial Hospital Staff, has studied these questions for several years, and a number of papers have been published regarding them.[1,2,3,4,5,6] Each of these contributions has dealt with a specific part of the problem, and either with one type of implant or with those within a limited range of sizes. Although some information has been given regarding correlation of data for different types, it has not been complete. The object of the present paper is to give specific information regarding the physical characteristics mentioned above, and to present data by means of which the minimum dose delivered within a given mass may be calculated for any practical scheme of interstitial irradiation.

The question of a satisfactory unit for tissue dosage of radiation has not been settled. There are many difficulties in the way of actually measuring the radiation where it is used. At present, for external

* Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

irradiation, some variation of the skin erythema dose is usually used as the unit. It is desirable, if possible, to use the same one for interstitial irradiation. Naturally it is not practicable to introduce the seeds or needles at specified positions under the skin and study erythema production, but a satisfactory substitute scheme can be employed as follows: Beeswax has been shown to have properties of absorption and scattering very similar to those of tissue, and can therefore be used as a tissue substitute in such a method as that shown in Figure 1. A radon tube is fastened in place on a piece of beeswax, A, about 10 cm. in diameter and of known thickness. It is covered by another block of wax, B, several centimeters thick, and the whole strapped to the skin of the thigh, as indicated. For each thickness of A, trials are made with various exposures until the dose is found which produces the threshold erythema reaction, that is, a faint reaction in 80 per cent of all cases, and no visible change in the remaining 20 per cent. This is assumed to be the dose which would also produce the threshold erythema reaction if it were buried in the tissue at the same distance beneath the skin as the wax supports it above. By this means it was discovered that tubes 12 mm. long, with filter equivalent to 0.5 mm. of platinum, and strengths such that the exposures varied between one and three hours, produce a threshold erythema at a distance of 1 cm. in tissue with an irradiation of 150 mc-hr. For other distances, threshold erythema doses were obtained as shown in Table 1.

TABLE I

THRESHOLD ERYTHEMA DOSES AT DIFFERENT DISTANCES IN TISSUE

Implant 12 mm. long; filter equivalent to 0.5 mm. gold or platinum

Distance Mm.—center of tube to skin	Dose Millicurie-hours
0.75 (surface application)	2.15
2.5	13
5.0	40
10.0	150
15.0	430

These erythema doses are all determined for exposures of not more than a few hours. Implants are, however, commonly left *in situ* for several days, or longer, and in such a case it would be necessary to use a larger quantity of radiation in order to produce a visible effect. There are few experimental data on the increase necessary. It would doubtless be different for an irradiation of a day or two, and one of a week or ten days, and might differ for each added day. To attempt to measure this and allow for it in dosage tables would mean both an enormous amount of experimental work, and complicated tables. It seems simpler, in the present stage of interstitial irradiation, to say that the erythema dose established as a unit shall be that produced by an irradiation of not more than a few hours' duration. Thus it is approximately the same dose as that used in external irradiation. The time factor should be included in a statement of dosage by mentioning the length of time during which the implants were in place. If subsequently the time factor is more thoroughly investigated, a ratio can be established between this erythema dose and some new unit yet to be established.

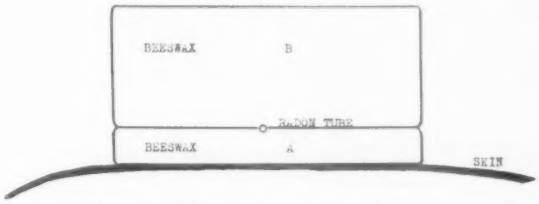

FIG. 1. Diagram illustrating method of determining threshold erythema dose for interstitial sources.

In Table 1 has been given the irradiation necessary to deliver a unit dose at different distances, for a specific type of implant. Similar measurements could be made for other types, and for greater distances. As an experimental method, however, this is not very satisfactory. In order to obtain accurate values of the threshold erythema dose, it is necessary to make a good many

tests, each of which must be observed at intervals for at least a month. It would be much more convenient to have a test which could be made in the laboratory, and a reaction which developed more promptly.

Two such reactions have been used for furthering the study—the bleaching of butter, and the production of necrosis in the dorsal muscles of rabbits. Both of these methods were used within the same range

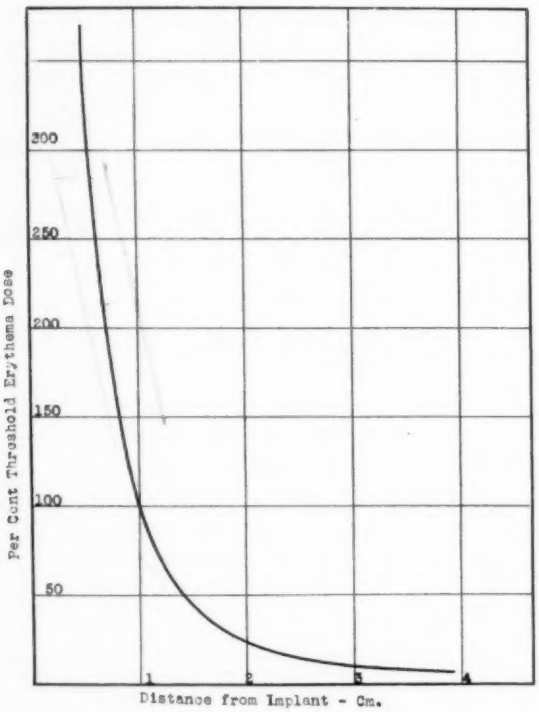

Fig. 2. Curve showing doses (in terms of threshold erythema) delivered at different distances in tissue from an implant 12 mm. long, filtered by 0.5 mm. platinum, for an irradiation of 150 mc- or mg-hr.

of distances as the erythemas, and the butter, in addition, was useful for distances up to several centimeters from the source. As supplementary data, at these longer distances, certain ionization measurements were applicable to the problem.

It is not the intention at this time to go into details regarding these measurements; they have all been presented elsewhere.[1,5,6] The important thing is that the rate of change of effect with distance in the medium was found to be practically the same for all these types of investigation. Naturally the quantity of radiation needed to produce a specific effect at a definite distance was different for the different reactions. But for each reaction, if the quantity required to produce the effect at a specified distance was called 100 per cent, the quantity necessary to produce it at other distances varied in approximately the same ratios as for all of the others. Therefore it is possible to combine all the data from the various experiments and obtain a curve or table expressing the variation of intensity of radiation with distance within the tissue from any specific implant. If the distance at which this implant delivers 1 T.E.D. (threshold erythema dose) is known, the curve can be plotted in terms of T.E.D. delivered at various distances. From Table 1 it is seen that an implant 12 mm. long, filtered by 0.5 mm. of platinum, delivers 1 T.E.D. at a distance of 1 cm. with an exposure of 150 mc-hr. Figure 2 shows the doses delivered at other distances from this implant, for the same exposure. From this curve, and within the given range of distances, all the necessary information can be obtained regarding this particular implant. If the exposure is changed, the dose delivered at a given point will be changed in the same ratio. However, it must be remembered that the distance at which a given dose is delivered is not varied in the same manner. For instance, an exposure of 300 mc-hr. will deliver 2 T.E.D. at 1 cm. It will not, however, deliver 1 T.E.D. at 2 cm. but at the distance which receives 0.5 T.E.D. from 150 mc-hr., namely 1.4 cm.

If either the filter or the length of the implant is changed, the above curve does not hold, but a correction must be applied. The extent of this correction has been determined by experiments of the types discussed above, and the results published.[5] The effect of change in filtration is shown in Table II, for distances from 0.5 to 2 cm., a filter of 0.5 mm. of platinum being taken as standard. As the filter becomes less, more radiation is delivered to the tissues, but this difference is not the same for all

distances from the source. At short distances, very light filters deliver considerably more radiation, but this is mainly of the beta-ray type, and is absorbed in a few millimeters of tissue. The greater the distance, the more closely do doses from implants with different filters agree. However, even at 2 cm., there are appreciable differences between those from lightly, and more heavily filtered sources.

tance at which a given dose is delivered by a given implant, or, conversely, the greater the amount of radiation necessary to deliver 1 T.E.D. at a given distance. In Table III are given, for needles of various lengths, each with 0.5 mm. platinum filter, the quantities of radiation necessary to deliver 1 T.E.D. at a distance of 1 cm. In this and succeeding tables, amounts of radiation are given, for convenience, in terms both of millicurie- or milligram-hours and of millicuries-destroyed.

TABLE II

VARIATION IN QUANTITY OF RADIATION DELIVERED AT DIFFERENT DISTANCES IN TISSUE, WITH VARIATION IN FILTER

Distance mm. (from center of implant)	Percentage of Radiation Delivered					
	Filter					
	Gold or Platinum			Steel, Brass, or Monel		Glass Seed
	0.2 mm.	0.3 mm.	0.5 mm.	0.25 mm.	0.5 mm.	
Surface of implant	135	116	100	327	164	3,670
5	111	105	100	142	124	214
6	107	104	100	130	121	185
7	105	103	100	127	119	167
8	105	103	100	126	118	158
10	105	103	100	125	118	145
15	105	103	100	124	118	140
20	105	103	100	124	118	135

The length of the implant is a very important factor. For a given number of millicurie- or milligram-hours, the longer the radiating source, the shorter the dis-

TABLE III

QUANTITIES OF RADIATION NECESSARY TO DELIVER 1 THRESHOLD ERYTHEMA DOSE AT 1 CM. FROM NEEDLES OF VARIOUS LENGTHS

Filter—0.5 mm. Pt

Length of Needle cm.	Quantity of Radiation	
	mc- or mg-hr.	mc-destroyed
0.5	115	0.85
1.0	130	1.0
1.5	144	1.1
2.0	158	1.2
3.0	186	1.4
4.0	220	1.6
6.0	285	2.1
8.0	370	2.8
10.0	475	3.6

Table IV shows the combined effect of distance and length of implant. In it are given the percentages of 1 T.E.D. delivered at different distances in tissue from needles of various lengths, filtered by 0.5 mm. of platinum, for a total irradiation of 1 millicurie-destroyed, or 133 millicurie-hours.

While the distance to which a given dose is delivered varies considerably with the length of the source, the total volume within which a specified minimum dose is delivered does not change nearly so much, for the same number of millicurie-hours delivered in the same time. In Table V are given the results of an experiment in the bleaching of butter which shows this relation. Although the longest implant in this series is four times the length of the shortest, the volume of butter discolored is only

TABLE IV

PERCENTAGES OF THRESHOLD ERYTHEMA DOSE DELIVERED AT DIFFERENT DISTANCES FROM NEEDLES OF VARIOUS LENGTHS, FOR IRRADIATION OF 133 MC- OR MG-HR. (1 MC.-DESTROYED)

Filter—0.5 mm. Pt

Distance* cm.	Percentage Threshold Erythema Dose					
	0.5 cm. needle	1.0 cm. needle	2.0 cm. needle	4.0 cm. needle	6.0 cm. needle	8.0 cm. needle
0.5	400	270	195	130	90	65
1.0	100	78	67	51	40	30
1.5	44	36	32	27	23	19
2.0	28	23	20	18	16	13
3.0	14	12	11	9	8	7
4.0	7	6	6	5	5	4

* These distances are all measured along a line perpendicular to the needle at its center.

8 per cent less. Of course, the shapes of these bleached volumes are quite different as shown by the dimensions of the cross section, the first length given in each case being the diameter of the bleached region perpendicular to the needle, the second that along the needle.

TABLE V

VARIATION IN AFFECTED VOLUME WITH LENGTH OF IMPLANT, FOR THE SAME TOTAL IRRADIATION

Length of Implant mm.	Volume of Bleached Butter cu. mm.	Dimensions of Cross Section mm.
3.8	2020	15.5×16.0
7.6	1980	13.9×19.6
12.0	1920	12.9×22.0
15.8	1860	12.0×25.6

From the data of Table IV, or curves plotted therefrom, as in Figure 3, the dose at any point on a line perpendicular to the middle of any implant can be found. For other points it is necessary to have a chart showing the distribution around the source. These have been published for needles of a wide range of lengths.[6] Figure 4 shows a set for a needle 4 cm. long. From such charts, the dose delivered at any point within the tissues can be found, for a given irradiation from any single implant.

Ordinarily, however, a number of seeds or needles are used in irradiating a tumor mass. Of course, if their relative positions are known, the doses at various points can be found for each one, and the sum obtained. Even if distances and positions within the tissues could be determined accurately, this would be a very laborious procedure; it is highly desirable to have some simpler means of determining dosage.

This problem was first studied from the point of view of gold radon seeds, 4 mm.

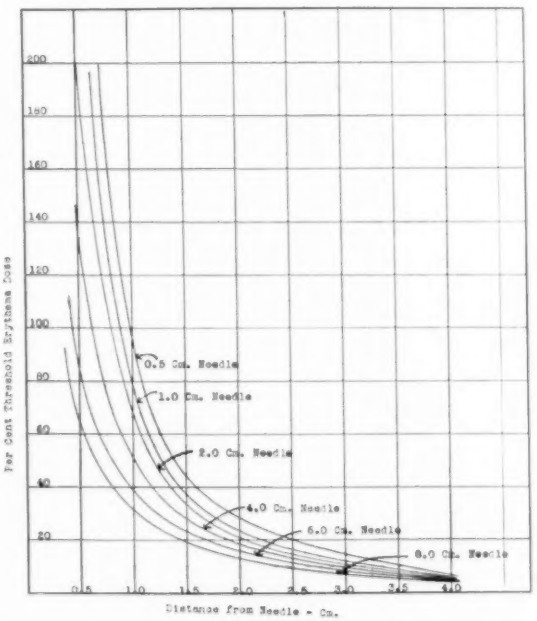

FIG. 3. Curves showing doses (in terms of threshold erythema) delivered at different distances in tissue from needles of various lengths, filtered by 0.5 mm. of platinum, for irradiations of 133 mg- or mc-hr. (1 mc-destroyed).

in length, with a filter of 0.3 mm. of gold. For such an implant, 110 mc-hr., or 0.8 mc-destroyed, will deliver 1 T.E.D. at a distance of 1 cm. in tissue. The curve of Figure 5 shows the dose delivered at other distances by this amount of radiation. For implants of this length, the distribution of radiation is practically uniform in all directions. From this curve were determined the total doses delivered at selected points in the neighborhood of various symmetrical arrangements of seeds, spaced at different distances apart.[2] It was considered that a certain minimum dose must be delivered to all cells within the lesion in order to produce the desired result. If the seeds are placed within the mass, points on the periphery receive smaller doses than any points within. The calculations show that, for spherical masses, if the radon is concentrated at the center, or distributed symmetrically within the inner half of the radius, the dose at the periphery (the minimum dose for any point within the sphere) is the greatest possible for a given amount of radiation. If the seeds are symmetrically distributed throughout the sphere, the number of millicurie-hours must be increased 25 to 30 per cent in order to deliver the same minimum dose at the periphery.

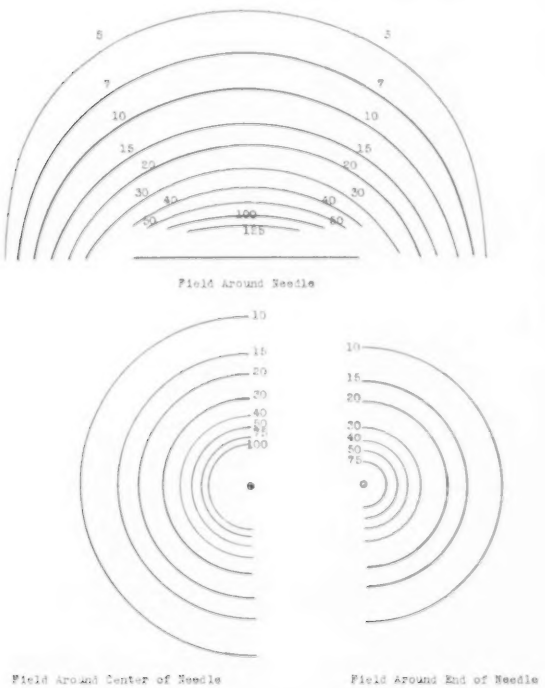

FIG. 4. Chart showing distribution of radiation around needle 4 cm. long, filtered by 0.5 mm. platinum, for an irradiation of 133 mg- or mc-hr. (1 mc-destroyed). Numbers indicate per cent T.E.D.

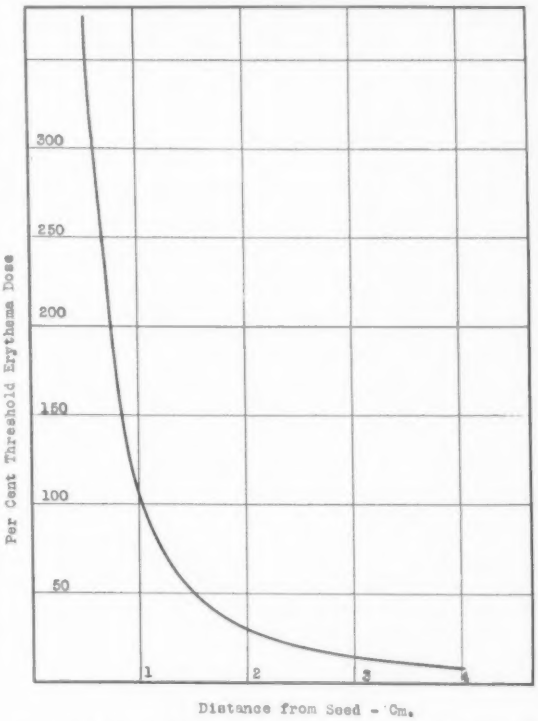

FIG. 5. Curve showing doses (in terms of threshold erythema) delivered at different distances in tissue from gold seed 4 mm. long, filtered by 0.3 mm. gold, for an irradiation of 0.8 mc-destroyed (110 mc-hr.).

For purposes of calculating tissue doses in a tumor, it is practicable to consider the mass as a sphere, or a group of overlapping spheres, the diameter being chosen just large enough to include the entire mass. A table was developed showing the number of millicuries, in these gold seeds, left in place permanently, necessary to deliver specified doses at the peripheries of various spheres, *if they were distributed within the inner half of* the radius. It is repeated here as Table VI.[4]

This table will not serve for needles more than a few millimeters in length, without further investigation, for when

TABLE VI

MILLICURIES IN GOLD SEEDS REQUIRED TO DELIVER SPECIFIED DOSES TO MASSES OF VARIOUS DIAMETERS

Skin Erythema Doses	Diameter of Mass—Centimeters											
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0
	Number of Millicuries											
1	0.2	0.5	0.8	1.5	2.0	2.4	2.9	3.4	4.0	5.4	7.0	9.0
2	0.4	1.0	1.6	3.0	4.0	4.8	5.8	6.9	8.0	11	14	18
3	0.6	1.5	2.4	4.5	6.0	7.2	8.7	10	12	16	21	27
4	0.8	2.0	3.2	6.0	8.0	9.6	12	14	16	22	28	36
5	1.0	2.5	4.0	7.5	10	12	14	17	20	27	35	45
6	1.2	3.0	4.8	9.0	12	14	17	20	24	32	42	54
7	1.4	3.5	5.6	10	14	17	20	24	28	38	49	63
8	1.6	4.0	6.4	12	16	19	23	27	32	43	56	72
9	1.8	4.5	7.2	14	18	22	26	31	36	49	63	81
10	2.0	5.0	8.0	15	20	24	29	34	40	54	70	90
11	2.2	5.5	8.8	17	22	26	32	37	44	59	77	99
12	2.4	6.0	9.6	18	24	29	35	41	48	65	84	108
13	2.6	6.5	10	20	26	31	38	44	52	70	91	117
14	2.8	7.0	12	21	28	34	41	48	56	76	98	126
15	3.0	7.5	13	23	30	36	44	51	60	81	105	135

they are used the radiating sources cannot be distributed in the same way as the gold seeds. Accordingly an extensive study was made of the dose delivered at different positions in the neighborhood of groups of needles of various lengths. This has been published in detail;[6] the method will be briefly described here. For needles whose active portions were 2, 4, 6, and 8 cm. long, with a filter of 0.5 mm. of platinum, charts of the type of Figure 4, and curves similar to those of Figure 5, were constructed. In addition to curves showing the relative intensities perpendicular to the center of the needle, similar curves were made for every half centimeter of its length. From these curves, for a point in the vicinity of a group of needles, the contribution to the total dose from each individual implant can be found. This is a long and tedious calculation for any specific case. In order to have some practical data, the doses delivered at certain set points for various groupings were calculated. From 2 to 12 needles of each length were considered, in four possible arrangements:

1. Lying 1 cm. apart, parallel to each other in a single plane.
2. As above, but 1.5 cm. apart.
3. Lying 1 cm. apart, half in one plane, the other half in a plane 1 cm. above the first.
4. As 3, but with 1.5 cm. spacing.

For each set of needles, of each length, in each arrangement, the dose was calculated at several specified points, and the results presented in the form of a table, which gave the dose delivered at each point in question for an expenditure of 100 mc-hr. *from each needle*. With any practical arrangement of needles, one of these specified points would probably correspond approximately to some point on the periphery of the lesion, and the actual dose delivered at this point from the radiation used could be calculated.

There has been a good deal of demand for a more usable table, and also for a definite correlation between gold seeds and needles. Accordingly such a table and correlation have been prepared, and are now to be presented here.

Since, when needles are used, it is customary to distribute them throughout the entire mass rather than in the inner portion, the gold seed data given in Table VI

are not applicable for the comparison (that being for implantation within the innermost part only). The amounts of radiation necessary for gold seeds distributed throughout the sphere, as stated above, are 25 per cent higher than those in the table, and it is these higher doses on which the correlation is based. The point to which the specified dose for gold seeds is applicable is one on the periphery of the sphere which just includes the lesion. For needles, it is necessary to select a point on the periphery which will be just as definite as this. Accordingly it is assumed that, when needles are distributed throughout a mass, as uniformly as possible (being placed parallel to each other, in one or two planes), the length of the mass is considered as the length of the needles, its width as 1 cm. more than the distance between the outermost needles, and its thickness as 2 cm. for a single plane of needles, and 2 cm. more than the distance between the outer planes, for more than one layer of implants. The typical point, which is assumed to receive the minimum dose, is then selected as 1 cm. above the needles, three-quarters of the way from their centers toward their ends, and midway between two at the outer edge of the series. A diagram (Fig. 6) will make this point more definite. The volume of the lesion is taken as the product of its three dimensions. As a matter of fact, such an approximation to the volume will include a certain amount of normal tissue, but so does the assumption of a sphere which will include all of the lesion. For needles of 2, 4, 6, 8, and 10 cm. lengths, arranged 2, 3, 4, 5, and 6 in a single plane, and arranged 4, 6, 8, 10, and 12 in two parallel planes, the number of milligram-hours necessary to deliver 1 T.E.D. at the specified point was calculated. Calculations were made for spacings of 1.0, 1.5, 2.0, 2.5, and 3.0 cm. These data, including values for gold seeds, are collected in Figure 6. The heavy line is drawn through the values for the gold seeds, when they are spaced throughout the lesion. The various types of points indicate values for needles, of various lengths and spacings. For a specific volume, the values for the chosen point agree fairly well, whatever type and arrangement of implants is chosen.* The range of variation may be seen from Table VII, in which the maximum and minimum doses for certain volumes, as shown by the calculated points, are listed, together with the values from the curve. The greatest variation is about 10 per cent. Errors of this magnitude are inherent in any type of interstitial irradiation in use at present. The data here presented are based on assumptions, which have been specified,

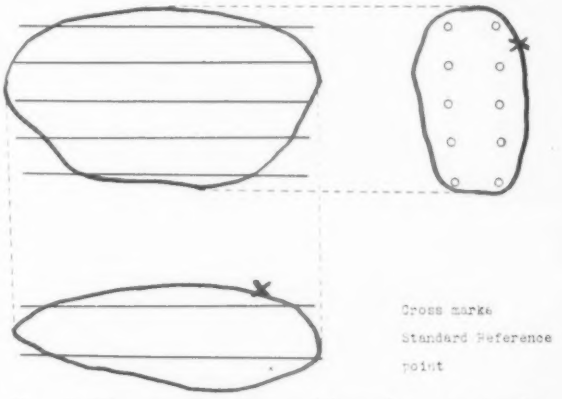

FIG. 6. Diagram showing position of standard reference point for dosage table.

and are not meant to be used as accurate specifications of dosage, but as useful approximations thereto.

It should be noted that when the needles are widely spaced, the dose per needle must be considerably greater than when they are close together. Such large individual doses may produce undesirable effects (necrosis) in the immediate vicinity of the implant. This factor should be considered in planning the treatment.

Since a table is, in general, more convenient to use than a curve, there is presented in Table VIII a practical dosage table for interstitial irradiation, based

* It should be noted that these values are for gold seeds filtered by 0.3 mm. of gold, and for needles filtered by 0.5 mm. of platinum; these are the filters most commonly used. However, in Table II it has been shown that this variation in filter results in only 3 per cent difference in dose at distances of more than 1 cm. Accordingly the curve may also be applied to needles or seeds with slightly different filters.

upon the data given in the curve. No calculations have been made for needles placed in a grid, or in a spoke arrangement, but such good agreement has been found among the groupings tested that it seems reasonable to assume that the table may also be used for these other arrangements, provided the needles are not more widely spaced than 2.5 cm. As stated above, the volume is taken as the product of the three estimated dimensions. The upper half of the table gives the quantity of radiation, in milligram- or millicurie-hours, required to deliver as a minimum the doses specified in the left-hand column; the lower half gives the same data in terms of millicuries-destroyed. From this table can be determined either the dose which a given lesion has received from a specified treatment, or the quantity of radiation necessary to deliver a given dose. For example, to find the radiation necessary to deliver a minimum dose of 7 T.E.D. in a mass $2 \times 3.5 \times 5$ cm. The volume of this is 35 c.c., which may be considered as half way between 30 and 40 c.c. The required dose is then half way be-

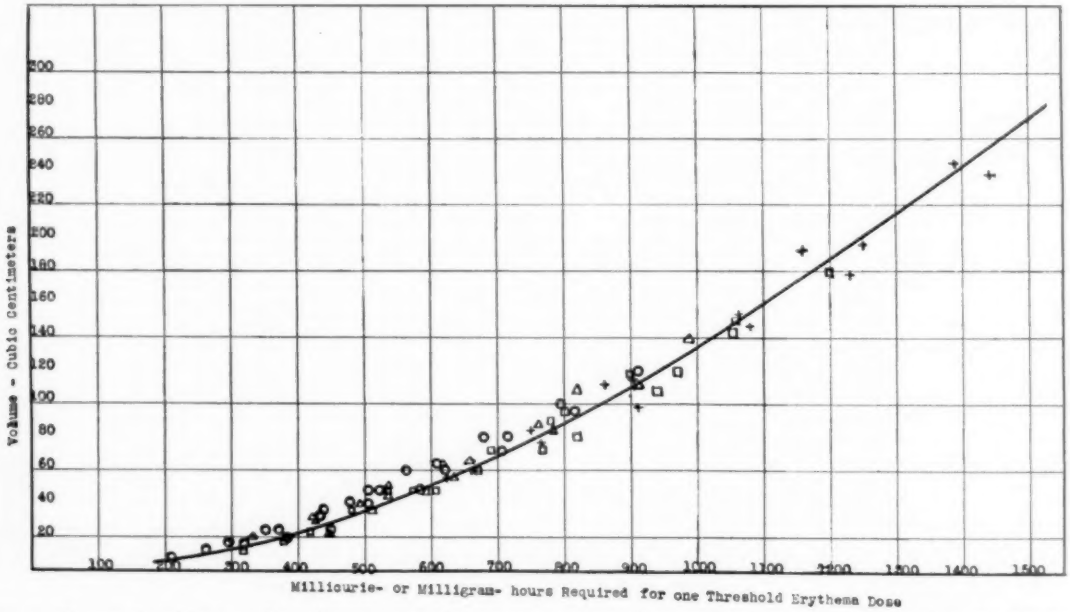

Fig. 7. Curve showing number of mg- or mc-hr. necessary to deliver 1 T.E.D. at standard point, for implants of any length, arranged as follows: Solid curve—Gold seeds distributed uniformly throughout mass. Circles—Needles 1 cm. apart parallel in one plane. Triangles—Needles as above, but 2.5 cm. apart. Squares—Needles 1 cm. apart in two parallel planes. Crosses—Needles as above, but 2.5 cm. apart.

Table VII

Variations in Calculated Quantities of Radiation Necessary to Deliver 1 T.E.D. at the Peripheries of Various Masses

Volume c.c.	Mc-Hr. for 1 T.E.D.			Maximum Variation from Curve per cent
	Minimum	Gold Seed Value	Maximum	
20	340	380	390	10
40	475	530	560	12
60	570	640	670	12
100	800	845	910	6
150	1030	1060	1080	3
200	1220	1250	1270	3

tween 3,290 mc-hr. for 30 c.c. and 3,710 mc-hr. for 40 c.c., or 3,500 mc-hr. This corresponds to 26 millicuries-destroyed. As an example of the converse type of problem, what is the minimum dose delivered in a mass 7×6×4 cm. with an irradiation of 6,000 hg-hr.? This is a volume of 168 c.c.; mg-hr. will deliver about 5½ T.E.D. to a 150 c.c. mass and a little less than 5 T.E.D. to a 200 c.c. mass. It will therefore deliver a minimum of about 5 T.E.D. to the lesion in question.

For such calculations it is not necessary to know the size or number of implants, but only that they are distributed fairly uniformly throughout the mass, reaching almost to its edges, but not extending much beyond it, and that the filter is equivalent to 0.3 to 0.5 mm. of gold or platinum. For a filter equivalent to about 0.5 mm. of steel, the dose delivered by a given amount of radiation will be about 15 per cent higher.

It should also be remembered, in using this table, that it is strictly applicable to irradiations of a week or more, and that when the time is less than five days, some allowance should be made by decreasing the quantity of radiation used.

The values obtained from this table are approximations to the actual *minimum* dose delivered in a given mass. Most of it receives considerably more. The estimation of the volume is subject to some error, and the placing of the implants may vary from that which the clinician intends. However the data will give a satisfactory indication of the dose delivered, and the table makes possible a direct comparison of doses of interstitial radiation given by quite different types of implants.

TABLE VIII

QUANTITIES OF RADIATION NECESSARY TO DELIVER SPECIFIED MINIMUM DOSES IN VARIOUS VOLUMES*

Interstitial Sources, Filter 0.3–0.5 mm. Pt

Threshold Erythema Doses	Volume—Cubic Centimeters															
	10	20	30	40	60	80	100	125	150	200	250	300	350	400	450	500
	Millicurie- or Milligram-Hours															
1	275	380	470	530	650	750	845	955	1060	1250	1410	1590	1730	1870	1990	2110
2	550	760	940	1060	1300	1500	1690	1910	2120	2500	2830	3180	3460	3740	3980	4220
3	825	1140	1410	1590	1950	2250	2535	2865	3180	3750	4240	4770	5190	5610	5970	6330
4	1100	1520	1880	2120	2600	3000	3380	3820	4240	5000	4660	6360	6920	7480	7960	8440
5	1375	1900	2350	2650	3250	3750	4225	4775	5300	6250	7070	7950	8650	9350	9950	10550
7	1925	2660	3290	3710	4550	5250	5915	6685	7420	8750	9900	11130	12110	13090	13930	14770
10	2750	3800	4700	5300	6500	7500	8450	9550	10600	12500	14100	15900	17300	18700	19900	21100
	Millicuries-Destroyed															
1	2.1	2.9	3.5	4.0	4.9	5.6	6.4	7.2	8.0	9.4	10.6	12	13	14	15	16
2	4.2	5.8	7.0	8.0	9.8	11	13	14	16	19	21	24	26	28	30	32
3	6.3	8.7	10.5	12	15	17	19	22	24	28	32	36	39	42	45	48
4	8.4	12	14	16	20	22	26	29	32	38	42	48	52	56	60	64
5	10.5	14	18	20	24	28	32	36	40	47	53	60	65	70	75	80
7	15	20	24	28	34	39	45	50	56	66	74	84	91	98	105	112
10	21	29	35	40	49	56	64	72	80	94	106	120	130	140	150	160

* These doses are for needles to be left in place four days or longer. If they are to be removed in a shorter time, all quantities of radiation should be somewhat smaller.

SUMMARY

Data regarding various types of interstitial sources of radiation are correlated, and results tabulated in convenient form for use.

All dosage data are expressed in terms of the same unit as that used in external irradiation, the threshold erythema dose. This unit has been experimentally established for interstitial irradiation.

Tables are given showing the effect on dose of change in filter and length of implants, and of variation in distance in tissue.

The doses delivered to certain points in the neighborhood of groups of implants of different lengths have been calculated. From these results a curve and a table have been developed, making possible the determination of the minimum tissue dose delivered in a given mass, from a specified irradiation, for any type of interstitial sources in general use at present.*

* For discussion see page 337.

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Vol. 33, No. 3

DROSOPHILA EGGS IN RADIUM DOSIMETRY*

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THE difficulties now standing in the way of determining the intensity of gamma rays by the air ionization method make necessary the use of less direct means of measurement. Thus, if an exposure to these radiations produces in some physical or biological test object, under standard conditions, the same effect that is produced by a measured dose of roentgen rays, we can say that the two doses are equal. But it cannot be assumed, without further proof, that by this method we have actually measured the activity of the gamma rays in roentgens. The term "equivalent roentgens" is more appropriate.

To choose a biological reaction as a secondary standard is natural; indeed, the first and most widely used measure of dosage was the erythema. This test has proved unsatisfactory because, as Holthusen[2] points out, the amount of effect varies with the intensity of the incident beam. Five hundred roentgens delivered in one minute produces a typical reaction, but if this dose is delivered in one hour, the response is very slight. To produce an erythema in this length of time 1,000 roentgens must be given. The influence of the time factor led Regaud and Ferroux[5] to remark that the erythema has no significance in dosimetry independent of the time.

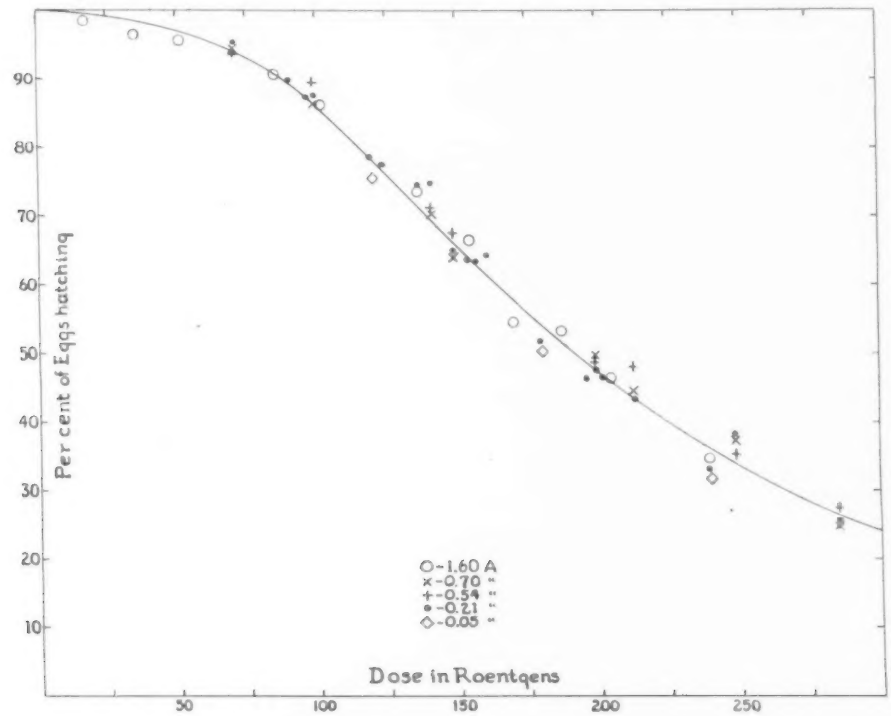

FIG. 1. Curve showing the percentage of *Drosophila* eggs hatching after roentgen doses ranging from 20 to 280 r. The results of tests made with wave lengths ranging from 1.60 to 0.05Å are indicated by different symbols and demonstrate that equal doses produce equal effects regardless of the wave length.

* From the Institute of Cancer Research, Columbia University, New York. Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

Another biological test object avoids this difficulty. The eggs of the fruit fly, *Drosophila melanogaster*, are practically free from the influence of the time factor. Furthermore, they are independent of wave length effects within very wide limits. Many experiments[4] have shown that carefully measured doses of roentgen rays produced at voltages ranging from 12 to 550 kv. elicit the same amount of reaction. Whether they will show a similar freedom from wave length effects in the region of the gamma rays cannot be proved until these very short waves have been successfully measured in terms of roentgens by physical means.

The method of measuring intensities of radiation by means of the fly eggs can be understood by reference to Figure 1. The data show that equal doses, measured in each case by air ionization chambers, produce equal effects, as determined by the proportion of eggs surviving after exposure. From these data a curve is plotted whose course shows the number of roentgens required to kill any percentage of eggs. One hundred and ninety roentgens kills 50 per cent. This result, obtained year after year in very many tests, has recently been confirmed by Jüngling and Langendorff.[3]

The method can now be reversed. If a beam of unknown intensity kills half of the eggs after an exposure of ten minutes, the eggs must have received 190 roentgens at the rate of 19 r/min. The precision of such measurements is satisfactory. In experiments with grenz rays, the intensity, determined by this biological method, differed from that obtained by the most careful ionization readings by less than 1 per cent.

An equal precision can be expected when this method is used to determine, in equivalent roentgens, the output of a radioactive preparation. Already I have made tests with two types of applicators. The results, expressed in equivalent roentgens per mg-el-hr. are in fair agreement with those obtained by several workers in Germany who have used *Ascaris* eggs as a test object.

Practical application of the biological method of calibrating gamma rays has been made by Braun[1] who found by this means that the erythema dose for his applicator was about 800 equivalent roentgens. When a roentgen-ray dose of equal size was applied to the same patient, the length of exposure and the area under irradiation being the same as in the radium test, the two erythemas were alike. While this test alone does not prove that the biological method reveals the intensity of gamma rays in actual roentgens, it demonstrates that this secondary means of calibration has a practical value in dosimetry.*

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* For discussion see page 337.

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CLINICAL CONSIDERATIONS INFLUENCING RADIUM DOSAGE*

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CLINICAL factors influencing radium dosage may depend on the general state of health of the patient or on local conditions in the tumor and tumor bed. Radium dosage may have to be reduced in extreme old age, heart disease, alcoholism, diabetes, etc.; or because of the anatomic location and accessibility of the growth; or its proximity to important normal structures, poor vascularization and infection of the tumor and tumor bed. In planning intensive radium therapy these considerations are especially important as the estimation of dosage on the basis of the microscopic structure of the tumor has not as yet proved generally dependable. This last mentioned factor is discussed in other papers in this symposium.

Heart Disease. In compensated cardiacs, intensive radium therapy has, in a few cases, been complicated by fibrillation and decompensation.

CASE I. A compensated cardiac, aged sixty-two, with a squamous cell epithelioma of the tongue and bilateral cervical node metastases, received in five days, 3,000 mg-hr. interstitially in and about the tumor. At the time of implantation his heart was regular. The next day fibrillation began and two days later decompensation. The decompensation disappeared within a few days under medical care, but the fibrillation continued unchanged. Six weeks later he was able to support intensive roentgen therapy to both sides of the neck. He died suddenly after six months, probably from heart disease though with the epithelioma persisting locally.

Alcoholism. Intensive radium therapy to the region of the upper respiratory and digestive tracts is not well tolerated by elderly, chronic alcoholics. Their general resistance seems lowered and bronchopneumonia not infrequently terminates an otherwise successful treatment.

CASE II. A chronic alcoholic, aged sixty-one, with a squamous cell epithelioma of the anterior right half of the floor of the mouth with right submaxillary metastases, was given a radium pack over both submaxillary and submental regions (70,000 mg-hr. at 6 cm., field of 425 cm.^{2} in a period of 8 days). Three days later the usual radio-epithelitis appeared and for the next week the patient's general condition remained satisfactory. He then developed signs of bronchopneumonia and died two weeks after completing the treatment. The clinical diagnosis was bronchopneumonia and septicemia.

Diabetes. The presence of diabetes calls for extreme caution in radium dosage, particularly when interstitial use of radium is planned.

CASE III. A diabetic, aged seventy-seven, with a 1 per cent glycosuria, and in fair general condition, was given interstitial radium therapy for a squamous cell epithelioma of the floor of the mouth and tongue. Eleven 2.5 mg. needles were inserted through the tongue into the sublingual region. Three hours later the tongue became edematous and the next day the swelling had extended to the submental and submaxillary regions. It had been planned to leave the needles *in situ* for five days, but in view of the increasing swelling they were removed on the third day, though only 2,000 mg-hr. had bene administered. There was a prompt regression of the enlargement in the left submaxillary and submental regions, but the swelling on the right side of the neck continued increasing. The temperature rose to 103°F., the glycosuria to 3 per cent and the blood sugar to 300 mg. Insulin was administered with but little effect. The swelling in the right submaxillary region gradually extended to involve the entire neck in a typical Ludwig's angina and the patient died eleven days later.

Anatomic Site. The anatomic site of the cancer has a bearing upon radium dosage: partial destruction of the tumor bed in the

* Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

treatment of epitheliomas of the lower lip, cervix uteri, or skin, does not preclude clinical arrest of the lesion; on the other hand, a similar injury to the normal structures underlying an epithelioma of the *esophagus* may be followed by perforation, mediastinitis and death.

Case iv. A patient with a transitional cell epithelioma of the upper third of the *esophagus* showed improvement for six months after roentgen therapy (200 kv.) and a dosage of 2,000 r over each of two anterior and two posterior fields. Dysphagia recurred and he was given 2,000 mg-hr. of radium filtered through 1 mm. Pt in a 13 cm. catheter. Two weeks later the original series of roentgen treatments was repeated with improvement of the dysphagia for two months. Gastrostomy was then required. Two weeks postoperatively, the patient developed a bronchopneumonia which terminated in death. Autopsy revealed an esophagotracheal fistula, bilateral bronchopneumonia, metastases in the lungs, but no cancer in the esophagus. The cause of death was probably aspiration bronchopneumonia, made possible by destruction of the tumor bed which supported the primary epithelioma of the esophagus.

Eye. Proximity of the eye demands special precaution. Ulcerations, opacities and cataracts may follow intensive radium therapy unless the cornea and lens are protected, particularly from unfiltered radiation.

Case v. A dose of 1,000 mc-hr. (1 mm. Pt in 1 cm. pack, field 2 × 2 cm.) was advised for an epithelioma of the lower eyelid to be treated in another hospital. Three 25 mc. radon capillaries enclosed in 1 mm. Pt tubes with ends sealed with paraffin, were used. The ends of the tubes were directed toward the eye. A few days following radium therapy a severe conjunctivitis with ulceration of the cornea developed, and three weeks later a glaucoma which required enucleation in two months.

Sole of the Foot. The sole of the foot is a weight-bearing surface exposed to constant trauma and its resistance is poor to intensive radium therapy. If, in addition, there has been any interference with vascularization of this region, e.g., after operative procedures, radionecrosis is especially apt to follow.

Case vi. A Kaposi sarcoma of both soles of the feet was treated by 1 cm. radium packs filtered through 1 mm. Pt, six weeks after partial excision and Thiersch grafts. The right foot was somewhat over-irradiated in that a dose of 5,460 mg-hr. was given over an area 9.5 × 7 cm. in a month. The sole of the left foot, however, received 3,120 mg-hr. over an area 6 × 7 cm., a dose which is well tolerated on other parts of the body. The tissues of both soles underwent radionecrosis and required repair with full thickness grafts.

Base of Tongue. The base of the tongue and other parts of the upper respiratory and digestive tracts deserve special consideration from the standpoint of radium dosage. Aspiration bronchopneumonia and lung abscess may follow the intense mucous membrane reaction which is essential for clinical arrest of epitheliomas arising in this region. This is more frequent when interstitial radium therapy is used and makes external irradiation preferable in radiotherapy of these cancers. A deeply ulcerated cavity in the base of the tongue may act as a reservoir for aspirating particles of pus into the lung.

Case vii. A man, aged fifty-eight, with an infiltrating, ulcerated squamous cell epithelioma of the base of the tongue, with edema of the epiglottis and bilaterally enlarged carotid nodes, was given 1,500 mg-hr. in seven needles into the base of the tongue. The usual radioepithelitis of the mucosa followed and eleven days after removal of the needles an external radium pack was applied. After six and one-half hours the pack had to be removed because of dyspnea and cyanosis. During the next five days, the patient apparently completely recovered from this attack, and the pack was reapplied for four days, at which time it again had to be removed because of recurrence of the same symptoms; 41,300 mg-hr. was thus given over the submaxillary and submental regions at a distance of 7 cm. and a field of 300 $cm.^2$ After the pack was removed, examination revealed that though the infiltration at the base of the tongue had lessened, the ulcer was deeper, and that the attacks of choking were probably due to laryngeal spasm secondary to edema. The

next day the patient developed signs of bilateral bronchopneumonia and a month later a lung abscess in the left lower lobe. Vincent's spirochetes and short chains of streptococci and staphylococci were found in the sputum. The patient gradually grew worse and died five months after beginning treatment. The two most interesting findings at autopsy were: the ulcer at the base of the tongue had extended to involve the epiglottis, and a large spirochetal abscess in the left lower lobe of the lung.

Bone and Cartilage. When squamous cell epithelioma invades bone or cartilage it usually cannot be arrested by radium therapy alone.

Case VIII. A squamous cell epithelioma of the left ear which had perforated the cartilage of the auricle was treated by cross-firing with a 1 cm. radium mold, 2,300 mg-hr. being given over a field 4 × 6 cm. in four days. The epithelioma regressed for three months and then reappeared, grew rapidly and necessitated amputation of the external ear.

Case IX. A baso-squamous cell epithelioma of the skin of the chin was exposed to 32,400 mg-hr. of radium in a 6 cm. mold, field 10 × 15 cm., over a period of a week. Three months later all visible evidence of disease had disappeared, but a roentgenogram of the mandible showed several areas of absorption beneath the former site of the epithelioma. Resection of the invaded part was advised, but refused as the patient considered himself cured. He remained well for about eighteen months when the lesion reappeared externally and intraorally. He delayed consent for resection for another six months. By that time, the disease had become too extensive for surgical interference and the patient died from cancer a year later.

Estimation of radium dosage for cancers in close proximity to superficially placed cartilage or bone is difficult. Ulceration of the skin or mucous membrane favors the extension of infection to the underlying bone. The likelihood of osteomyelitis is further increased by the addition of intensive radium therapy. Surgical removal of bone prior to treatment with radium may lessen the possibility of this complication.

Case X. A man, aged fifty, with a squamous cell epithelioma of the left sublingual region and gum of the adjacent mandible had a severe Vincent's infection of the gums and a small area of osteomyelitis of the mental portion of the mandible. The infection could not be completely eradicated, but as the epithelioma was growing rapidly, it was decided to start radium treatment. Six 3.5 mg. needles were inserted in and around the lesion and 1,600 mg-hr. given in the ensuing five days. Two weeks later, a 6 cm. radium pack, field 10 × 10 cm., was applied and 50,000 mg-hr. given. The disease was temporarily controlled, but four months later another 1,600 mg-hr. in five needles was administered into persisting tumor nodules. Three months thereafter radionecrosis occurred in the sublingual region. Part of the lower border of the adjacent mandible became denuded of its mucous membrane and a sinus formed from the area of the osteomyelitis to the skin of the submaxillary region. The patient became cachectic and died eighteen months after beginning radium therapy. Death appeared to be due to chronic osteomyelitis of the mandible. Clinical evidence of the tumor had disappeared. Surgery had been discussed after the second radium treatment but was believed to be contraindicated because of the poor physical condition of the patient.

The considerations just mentioned for radium therapy near the mandible also apply to that of the skin of the toes. The thin layer of tissue overlying the phalanx is poorly vascularized and easily damaged, thus favoring radium necrosis.

Case XI. A melanocarcinoma near the metatarso-phalangeal joint of the left great toe was electrocoagulated. The resulting ulcer did not heal, but showed increasing growth of its edges, and on the assumption that this represented persistence of the neoplasm, was treated by a 1 cm. molded radium pack. A dose of 5,380 mg-hr. was given over a period of four days, to an area 40 cm.^{2} The patient was advised not to bear any weight on his foot, but soon disregarded this precaution. Three weeks later there was increasing pain in the great toe and enlargement of the ulceration which was regarded as a radionecrosis. Attempts to stimulate healing were made by curettage, ultraviolet irradiation and application of salves. There was only slight response and eight

months following radium therapy the toe was amputated. Tumor could not be found on microscopic examination of the removed toe, but all tissues showed regressive changes typical of radionecrosis. The patient remained well for three years, then developed inguinal and pelvic metastases and died from melanocarcinoma six months later.

Accessibility. The accessibility of the cancer is of prime importance and the technique and dosage of radium therapy are greatly influenced by it. Where intracavitary radium is the principal avenue of approach, the focal distance is short, the effect is greatest on tissues in close contact with the radium, while dosage in the more distant parts is insufficient. This accounts for the usual failure of intracavitary radium treatment of extensive inoperable carcinoma of the external auditory canal, rectum and esophagus (as illustrated by Case IV). Where cross-firing is possible, e.g., in epitheliomas of the lower lip and cervix uteri, the difficulty of insufficient dosage does not arise as often; on the contrary, over-irradiation is frequent. Failures after interstitial radium, not due to radioresistance inherent in the cancer, usually occur because of one of three reasons: (1) The limits of the irradiated field are too narrow as the extent of the growth has not been clinically appreciated. (2) The radiating foci and the intensity of irradiation are unequally distributed on account of the bulk of the tumor. (3) Puncturing infected surfaces for the introduction of radium containers facilitates the entrance of bacteria and increases the likelihood of deep infection and radionecrosis. Rarely, the point of the seed inserter or needle may pierce a blood vessel and cause hemorrhage.

The tendency of a tumor to grow out from the surface, or, on the contrary, to invade deeply, has a bearing on accessibility. Exuberating growths are less likely to infiltrate and to carry metastases and infection inwards. They are more easily traumatized, bleed readily and are recognized earlier. They may therefore be eradicated with greater facility than the infiltrating, deeply ulcerated growths which have opposite traits. If both characteristics are represented, the predominating is likely to determine the result of treatment.

The size of the field and the volume of tissue to be irradiated influence radium dosage. In the treatment of extensive cancers, radium dosage is not increased in direct proportion to the size of the fields; the dose per centimeter of irradiated field must be reduced when large fields are used. For instance, a dose of 400 mg-hr. per square centimeter of surface is not excessive for 1 cm. packs, 1 mm. Pt and field 2 × 2 cm., but might be dangerous for a field 10 × 10 cm.

Regressive Changes. Regressive changes in the tumor bed reduce the resistance of normal tissue to intensive radium therapy. It is well known that postoperative scars do not withstand irradiation as well as normal tissues. The same applies to changes due to preceding diseases, e.g., lupus, syphilis, etc.

Case XII. A patient with a squamous cell epithelioma arising on the basis of a scar from an old burn on the dorsum of the hand was advised to have the epithelioma excised in preference to treatment with radium. It was felt that the dose required for clinical arrest of the epithelioma was likely to cause radionecrosis of the poorly nourished, atrophic and scarred tumor bed.

Case XIII. A patient with syphilitic interstitial glossitis and a superficial squamous cell epithelioma occupying the anterior half of the tongue received 3,325 mg-hr. in twelve needles during six days. The distribution of the needles and the dose were similar to those used in other epitheliomas of the tongue without complicating interstitial glossitis, and had been tolerated very well. This patient, however, developed a radionecrotic ulcer in the center of the irradiated area six months after treatment which healed after five months. It was felt that the occurrence of radionecrosis had been favored by the interstitial glossitis.

Previous Radium Therapy. The radiosensitiveness of the tumor bed is increased by previous intensive radium therapy or

by sublethal radium doses repeated over a period of months or years. If the tumor is near the surface of the mucous membrane or skin, and especially if radium applicators are inserted through these infected areas, deep infection of the tumor bed may result.

CASE XIV. A patient with a 3 cm. cauliflower epithelioma of the dorsum of the tongue was treated interstitially with 3,724 mg-hr. in twelve radium needles. This was followed by temporary regression of the tumor with reappearance eight months later. Microscopically, this proved to be the same neoplasm and another 1,064 mg-hr. of radium in nine needles was administered. Radionecrosis of the treated area occurred one month later. After five weeks the ulcer was resected. The excised tissue microscopically showed well stained cancer cells. The tongue lesion has remained healed and the patient has been clinically well for three years, though cancer was found in the upper cervical nodes resected shortly before the operation on the tongue.

On rare occasions over-irradiation of previously irradiated tissues is successful in arresting an apparently hopeless case.

CASE XV. A man, aged sixty, with an extensive laryngeal epithelioma and metastases to the right upper cervical nodes, had received 60,000 mg-hr. to the right side of the neck and 44,000 mg-hr. to the left, at 6 cm., at another institution. The laryngeal lesion had been arrested, but the right neck still presented an irregular, hard, nodular, fixed mass, approximately 10 × 5 × 3 cm. This region was treated palliatively with three courses of roentgen therapy, 1,000 r each, during the next nine months. After each series of treatments, pain and the tumor regressed temporarily, and in a final effort for more permanent improvement, he was given 3,000 mg-hr. in thirteen radium needles inserted into the mass. Two months later this area broke down and for the next eight months the patient suffered severely. The pain then gradually subsided and, a year after radium treatment, the necrosis healed. The patient has now been free from symptoms and clinical evidence of cancer for sixteen months.

CASE XVI. A patient with a squamous cell epithelioma of the floor of the mouth, tongue, gum and bilaterally enlarged cervical nodes, had biweekly surface applications of radium intraorally and externally over the jaw, for a period of two and one-half years. On admission, he was given a radium pack over the submental and left submaxillary regions (71,000 mg-hr. at 6 cm., field 385 cm.^{2} in a period of eleven days). Four weeks later, thirteen needles were inserted through the tongue into the floor of the mouth and he received 3,000 mg-hr. over four days. There was immediate improvement in the local condition. During the ensuing eighteen months, however, there followed osteomyelitis and gradual sequestration of the more intensely irradiated left half of the mandible. The pain was excruciating until a sinus appeared from the area of osteomyelitis to the outside. For the past three and one-half years, the patient has been fairly comfortable and the local lesion has now remained arrested for a period of almost five and one-half years.

Damage to bone after intensive radium therapy may be latent but becomes appreciable if, subsequently, trauma and infection are added.

CASE XVII. A man, aged sixty-nine, with a squamous cell epithelioma of the right side of the tongue, recurring eight months after partial glossectomy, was given 42,000 mg-hr. in a 6 cm. pack to the right neck over an area of 140 cm.^{2} One month later he received 2,166 mg-hr. interstitially in seven needles in the tongue. He did well for seven months, when following extraction of a tooth in the irradiated area, he developed an osteonecrosis of the right half of the mandible. For fourteen months thereafter he suffered severe pain and trismus. A large sequestrum was finally removed from the involved area with immediate cessation of pain. His general condition improved, and at present, four years following the radium treatment, he is free from clinical evidence of disease.

Infection. If intensive radium therapy is used in the presence of infection of the deeper parts of a neoplasm, septicemia may result.

CASE XVIII. A very cellular sarcoma of the soft tissues of the left lumbar region, in a boy of fifteen, had been repeatedly incised on the supposition that it was an abscess. During the last operation, the surface of the ilium was curetted in an unsuccessful attempt to obtain pus. On admission six weeks later, the operative

wound was occupied by an ulcerated, exuberating, cauliflower mass 8 cm. in diameter and 3 cm. high. The temperature was 103° F., and the general condition fair. A molded radium pack, at a distance of 10 cm., field of 500 cm.², was applied and 55,500 mg-hr. given. The patient did well for a week, the mass receding partially and the temperature dropping to normal. Then the temperature again soared to 103°F., and five days later, there appeared petechiae, subcutaneous hemorrhages, and a flaccid paralysis of the right arm and leg. Although blood culture was reported negative, the clinical picture and death two weeks after completing treatment strongly suggested septicemia.

In protracted intrauterine radium therapy of epitheliomas of the cervix uteri, it is important to provide adequate uterine drainage so as to prevent peritoneal spread of uterine infection. Immediate removal of the uterine radium applicator is indicated if the temperature rises.

Case xix. A patient, with an infiltrating, infected epithelioma of the cervix uteri and bilateral parametrial involvement, had several days of intensive douching prior to roentgen therapy. After receiving 1,000 r over two anterior and 1,500 r over two posterior pelvic fields, radium was inserted in a uterine catheter (3 × 13.33 mg.) and a vaginal colpostat (2× 13.33 mg.). On the third day the patient developed a temperature of 104°F., which promptly fell to 100°F. upon removal of the applicators. Three days later the radium was reinserted. The temperature again rose to 102° F., but the radium was permitted to remain until the following day. The total dose given was 3,600 mg-hr. in the uterine canal and 3,300 mg-hr. intravaginally. The patient responded poorly, and additional roentgen therapy (2,300 r) over the right and left anterior pelvis did not deter death eight months later.

Case xx. Advice for treatment was given to another hospital for a patient with a deeply ulcerated and infected epithelioma of the cervix uteri. It had been counselled to give 3,000 mg-hr. in a uterine catheter and a similar dose in a vaginal colpostat over a period of five days. The applicators were to be removed daily, sterilized and reinserted after a cleansing vaginal irrigation. Everything went well for the first thirty-six hours of irradiation, and then the patient suddenly had a chill and temperature of 103°F. General physical examination was negative. Instead of removing the uterine catheter to allow for drainage, the irradiation was continued. On the third day, in view of persisting temperature, the radium was removed. The patient died three days later from a generalized peritonitis. Autopsy was refused but the clinical diagnosis was peritonitis from spreading intrauterine infection.

Infection in irradiated tissues frequently mimics cancer and may be mistaken for it.

Case xxi. A man, aged fifty-four, had a squamous cell epithelioma involving the anterior wall of the left antrum and invading the adjacent nasolabial fold. The anterior wall of the antrum was resected. Four 12.5 mg. tubes were then inserted into the antrum and two similar tubes into the adjoining nostril and a total dose of 3,270 mg-hr. of radium given. The skin overlying the aperture had been excised and the edges approximated with tension sutures. Two weeks later it broke down leaving a large opening into the antrum. For the next year the patient complained of excruciating pain and swelling of the irradiated maxilla. He developed an ascending infection of the ethmoid region and progressively went down hill. Fourteen months after treatment he developed amaurosis of the left eye and a complete left ophthalmoplegia with ptosis and exophthalmos, interpreted as probable extension to the left sphenoidal fissure and middle fossa of the cranium. His condition was very poor and he committed suicide. At autopsy, cancer could not be found anywhere. The left antrum and adjacent tissues showed only chronic inflammation. The eye symptoms were apparently secondary to infection and osteonecrosis. Radical surgery would have been indicated had the true nature of the disease been recognized earlier, and had the patient been able to withstand the shock of such a procedure.

Differential diagnosis between masses due to radionecrosis and those caused by cancer is at times impossible without biopsy. This is made especially difficult if the masses are in inaccessible locations, where biopsy cannot be done readily. Uncontrolled cancer, as well as radionecrotic

masses, may increase in size following radium therapy.

Case xxii. A man, aged forty-five, with a granular cell rhabdomyoma of the left border of the tongue was given 1,560 mg-hr. interstitially in five needles. A month later he received 35,000 mg-hr. to the left neck in a 6 cm. radium pack, over an area of 90 cm.^{2} Four weeks thereafter the tongue was still edematous and a new infiltration was palpated in the irradiated area. A biopsy showed a few nests of suspicious looking cells scattered through atrophic connective tissue. Because of this microscopic finding and the persistence of the swelling of the tongue, a partial glossectomy was done. An abscess cavity surrounded by a thick fibrous capsule accounted for the tumefaction. The granular cell rhabdomyoma had remained unaffected by the radium.

Case xxiii. A woman, aged forty-five, with an extensive epidermoid carcinoma of the cervix uteri involving both parametria, was given 4,100 mg-hr. intracervically and 3,800 mg-hr. intravaginally. One month later (extending over a period of forty days), she received 2,600 r of roentgen therapy (200 kv.) to the right anterior and posterior pelvis and 2,300 r over the corresponding left fields. The beams were so angulated as to cross at about the region of the cervix. The patient remained well for the next six months. She then developed diarrhea, rectal hemorrhage and a mass in the cul-de-sac surrounding the rectum on the right side. This was interpreted as a persistence and additional roentgen therapy was given as follows: 1,000 r each to two anterior and two posterior pelvic fields and 1,500 r through the perineum. Symptoms improved for two weeks and then recurred. As the perirectal infiltrate had remained unchanged, a last desperate attempt was made to palliate what was thought to be persisting neoplasm, and she received 2,900 mg-hr. in a 14 cm. rectal catheter. The infiltration increased still further and the patient's general condition grew worse. Three months following the last radium treatment she developed a rectovaginal fistula and died six months later. Autopsy revealed multiple ulcerations of the bladder, a chronic ulcerative proctitis, a rectovaginal fistula and bilateral bronchopneumonia. Microscopically, however, cancer could not be found anywhere.

Post-Radium Infection. The resistance of skin to infection is reduced by intensive radium therapy. Furunculosis, dermatitis and erysipelas originating in the irradiated areas are not uncommon following this treatment. Though this complication has no direct bearing upon radium dosage, it is an interesting sequel of intensive radium therapy.

Case xxiv. A boy, aged fourteen, who seven months previously had a resection and roentgen therapy for a fibrosarcoma of the pharynx, had a recurrence in the operative scar. He was given 25,575 mg-hr. at a distance of 6 cm. over a field of 90 cm.^{2} The masses regressed but did not disappear. Three months later he developed a rather severe erysipelas of the right neck and face. Curiously enough, the nodules shrank further during this illness. Erysipelas, after vigorous radium therapy, has been observed at a frequency which is out of proportion to its occurrence in non-irradiated skin.

Case xxv. Ten days following radium pack treatment of 36,250 mg-hr. at 6 cm., field 120 cm.^{2} in a patient who had a partial excision for a squamous cell epithelioma of the thyroglossal duct, the desired radio-epidermitis appeared. This reached its height in two weeks and then, instead of disappearing, was superseded by a vesicular dermatitis which spread in all directions beyond the irradiated area. This in turn began subsiding about a week later, and the patient did well for three weeks, when numerous furuncles and a carbuncle appeared in the irradiated area. A week later she developed skin metastases over the entire chest wall, rapidly lost ground and died two months later outside the hospital, the exact cause of death being unknown.

SUMMARY

1. Clinical indications for reducing radium dosage and some of the difficulties, complications and sequelae of radium therapy are reviewed on the basis of cases treated at the Presbyterian and Montefiore Hospitals, New York City.

2. The rôle of heart disease, chronic alcoholism and diabetes is discussed.

3. The importance of the site of the tumor is emphasized by quoting failures and radium injuries in cases of cancer of

the esophagus, eyelid, soles of the feet, base of the tongue and in proximity to bone and cartilage.

4. The relation between accessibility of the neoplasm and technique and dosage of radium therapy is mentioned.

5. The increase in radiosensitiveness of the tumor bed by regressive changes secondary to preceding disease or to radiotherapy is illustrated by case histories.

6. Clinical examples are given which show the influence of infection upon radium therapy.*

* For discussion see page 337.

VOL. 33, NO. 3

FACTORS INFLUENCING THE DETERMINATION OF RADIOSENSITIVITY OF CANCERS OF THE ORAL CAVITY AND UPPER RESPIRATORY TRACTS*

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IN THIS paper an attempt is made to evaluate the morphology of oral, nasal and laryngeal cancer in its relation to radiosensitivity. As Haagensen[1] has pointed out, radiosensitivity should not be considered synonymous with radiocurability. For the purposes of this discussion, all tumors which clinically seemed to disappear completely following irradiation either by roentgen rays or radium have been considered sensitive, regardless of whether or not they later reappeared. All tumors which did not disappear, even though reduced in size, and all tumors unaffected by irradiation, have been considered resistant. For this study there were available at the Presbyterian Hospital, New York, 112 cases which had had adequate irradiation and about which sufficient data had been recorded. Sixty-eight, or 60 per cent, were sensitive and 44, or 40 per cent, were resistant. They included 91 squamous cell epitheliomas, 9 lympho-epitheliomas, 7 sarcomas, 2 carcinomas, and one each of the following: mixed tumor, malignant melanoma, and granular cell rhabdomyoma.

At the outset it must be admitted that the material available for this study is inadequate. The number of cases is too few, and the types of irradiation, as well as the dosages used, have varied. Nevertheless, the facts brought out show certain tendencies which seem helpful in predicting relative radiosensitivity. It is well known that microscopic morphology is not an infallible guide to radiosensitivity. Therefore, it is necessary to approach that phase of the subject by a preliminary consideration of the other factors involved.

Chart 1† shows the relative radiosensitivity of the tumors, regardless of morphological type, according to the site of origin. This demonstrates again what is well known—that there is decided variation in relative radiosensitivity in different parts of the mouth and upper respiratory tract. The reasons for this great variation are probably many. They can be divided into (*a*) extrinsic factors, (*b*) cellular origin, (*c*) differentiation.

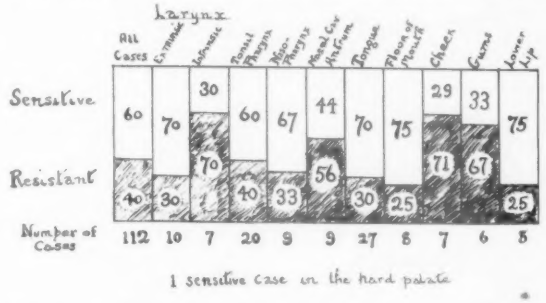
Larynx
All Cases
Sensitive
Resistant
Number of Cases
60 70 30 60 67 44 70 75 29 33 75
40 30 70 40 33 56 30 25 71 67 25
112 10 7 20 9 9 27 8 7 6 8
1 sensitive case in the hard palate

CHART I. Percentage variation in radiosensitivity according to anatomical site.

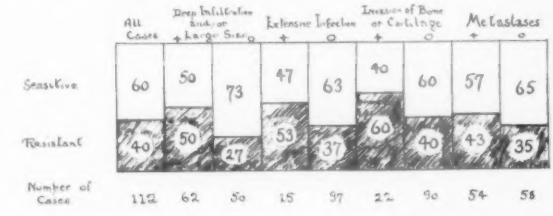
All Cases
Extensive Infection
Sensitive
Resistant
Number of Cases
60 50 73 47 63 40 60 57 65
40 50 27 53 37 60 40 43 35
112 62 30 15 27 22 20 54 58

CHART II. Percentage variation in radiosensitivity for various general factors.

(*a*) *Extrinsic Factors.* Chart II shows that tumors which have invaded bone or

† In each chart the shaded parts represent resistant tumors and the unshaded parts sensitive tumors. The relative proportion of each has been expressed in percentage figures for the sake of ready comparison. At the bottom of each column is given the actual number of cases.

* From the Surgical Pathological Laboratory of the College of Physicians and Surgeons, Columbia University, and the Presbyterian Hospital, New York. Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

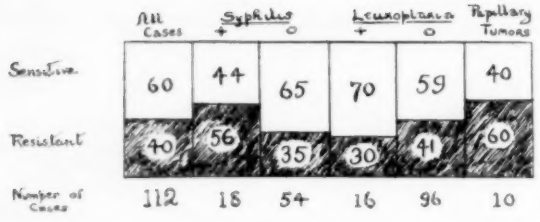

Chart III. Percentage variation in radiosensitivity for various general factors.

cartilage, which are markedly infected, which are very large or invade extensively are somewhat more apt to be resistant than if these features are not present, but in percentage points this difference is not very great. The presence or absence of clinical metastases seems to have no effect statistically. Syphilis (Chart III) is an unfavorable factor. On the other hand, leucoplakia was present in more sensitive than resistant tumors in this group. This may be explained by the fact that a considerable proportion of the epitheliomas accompanying leucoplakia were small or did not infiltrate deeply. Our experience does not confirm the statement of Stewart[3] that papillary tumors are more commonly sensitive. There are other extrinsic factors which possibly influence radiosensitivity, such as local and general anemia, arteriosclerosis, nephritis, diabetes, heart disease and preceding irradiation, but for various reasons these have not been investigated in this group. I would emphasize at this point, however, that in estimating the probable radiosensitivity of any given tumor it is wise to remember these general features. Perhaps the most important of them are size and accessibility—a small superficial tumor can be so heavily irradiated that it can be destroyed no matter how resistant. The real test comes in the larger and less accessible tumors where the dosage delivered is more problematical.

(*b*) *Cellular Origin.* In the next chart (Chart IV) is shown the radiosensitivity according to tumor type. Here we find that those tumors which come from radiosensitive parent cells, such as lymphosarcomas and lympho-epitheliomas, are also apt to be radiosensitive, but it is apparent that not all of them behaved in the expected fashion. For instance, a tonsillar small lymphocytic cell lymphosarcoma, which was resistant, was both very extensive and infected; the latter factor especially may have interfered with the effect of irradiation. The squamous cell tumors behaved in an average fashion, and the rest of the group are represented by isolated cases, but it is worth noting that the differentiated forms, such as fibrosarcoma, mixed tumor, adenocarcinoma, melanoma and granular cell rhabdomyoma, were all resistant.

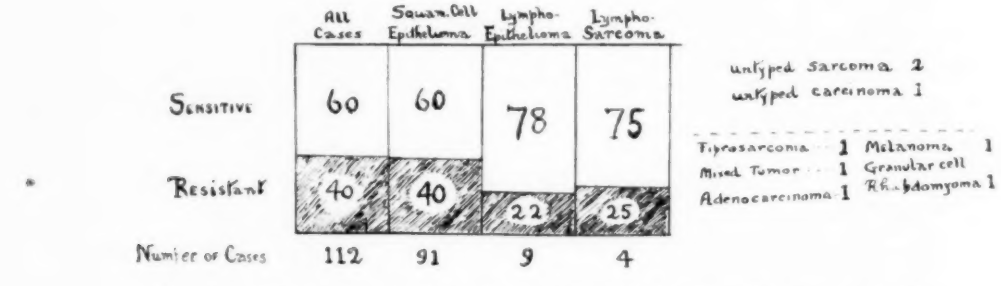

Chart IV. Percentage variation in radiosensitivity according to type of tumor.

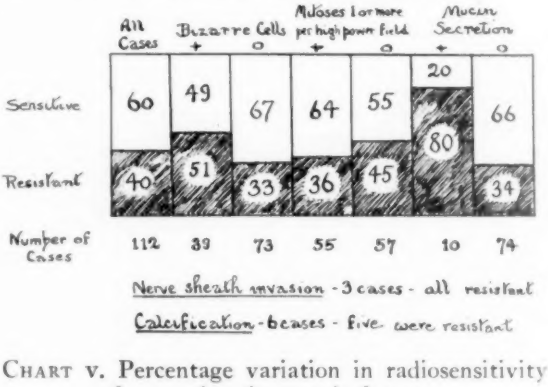
All Cases
Bizarre Cells + −
Mitoses 1 or more per high power field + −
Mucin Secretion + −
Sensitive
Resistant
Number of Cases
60 49 67 64 55 20 66
40 51 33 36 45 80 34
112 89 73 55 57 10 74
Nerve sheath invasion - 3 cases - all resistant
Calcification - 6 cases - five were resistant

Chart V. Percentage variation in radiosensitivity for certain microscopic factors.

(*c*) *Differentiation.* General Factors. The next investigation deals with certain features which have been suggested as indicating variations in differentiation or ripeness common to all tumors (Chart v). Thus, the presence of bizarre cell forms may be considered an indication of marked anaplasia, and frequent mitoses—frequent in this study meaning an average of one or more in every high power field—may be considered an indication of marked growth activity, both of which, it is stated, are common to the radiosensitive tumor. The chart shows that no such significance can be attached to them.

There are, however, other features which have definite significance if they are present. Those tumors in which mucin is secreted are markedly resistant as a group. This includes not only adenocarcinomas and mixed tumors but also certain squamous cell epitheliomas of the cheek, tongue, nasal cavity and lower lip, in some parts of which atypical glands are formed which secrete mucin. It is to be emphasized that this feature cannot be properly appreciated unless a special stain for mucin is used, as Regaud and Gricouroff[2] did with the epitheliomas of the cervical canal. The invasion of the lymphatic channels of nerve sheaths was noted in 3 cases, all of which were resistant. This is known to be an indication of great malignancy and these cases suggest that it may also be an indication of radioresistance. Calcification sometimes occurs when squamous cell epitheliomas contain large quantities of desquamated epithelial débris. When found, it is usually an indication of resistance.

Squamous Cell Epithelioma. In dealing with the squamous cell epitheliomas which form the vast majority of all the malignant tumors of these regions, four separate factors have been evaluated, i.e., the tendency to form (*a*) keratin; (*b*) intercellular bridges; (*c*) pearls, and (*d*) stratification. By stratification is meant the arrangement of the tumor cells in strata of basal and squamous layers, such as is seen in the epidermoid mucosae. The accurate determination of the presence or absence of these features is dependent upon proper fixation of the tissues and differential staining. The amount of keratin present can only be determined if a selective stain is used—the one used in this study was Masson's trichrome stain. This brings out the fact that some tumors which do not form pearls and

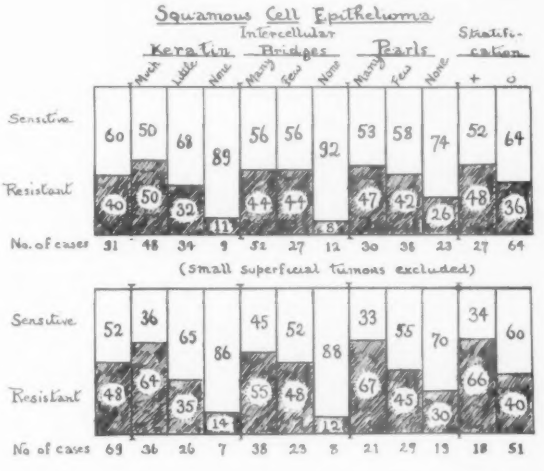

CHART VI. Percentage variation in radiosensitivity for certain microscopic factors.

show no evidence of stratification, nevertheless have large amounts of intracellular keratin and are resistant. The trichrome stain is also advantageous because it accentuates the intercellular bridges making their recognition easy. Chart VI shows that, in general, the more keratin, bridges, or pearls present, the greater the likelihood of radioresistance. The absence of keratin and bridges, although infrequent, is an even better guide to radiosensitivity. It seemed disturbing, however, to find such a large proportion of sensitive tumors among the cases with the greatest amount of keratin and the greatest number of bridges and pearls. Obviously, some of the other factors which have already been mentioned must have operated to interfere with the expected result. Since the small tumors—2 cm. or less in diameter—include many which are easily accessible and which received doses of irradiation capable of destroying the most resistant tumor, it might be supposed that a more accurate

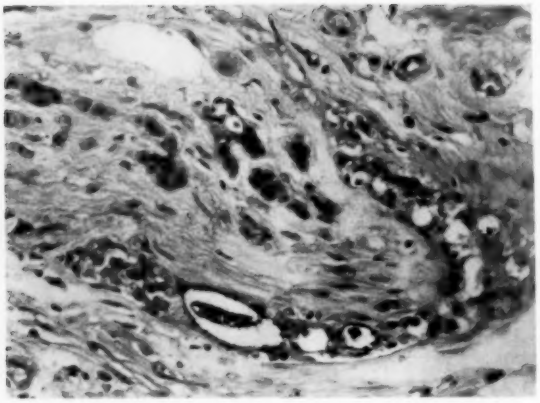

Fig. 1. Invasion of nerve sheath and mucin formation. Photomicrograph of the invasion of the lymphatics of a nerve sheath by a tumor which originated in the mucosa of the cheek near the left commissure. In many areas it was characteristic of a simple squamous cell epithelioma. Here and in a few other areas the cells have formed acini. In some of the lumina and within some of the cells lining them is a material (black in the photograph) which stains a brilliant red with mucicarmine. The tumor was very malignant and markedly radioresistant.

estimation of the relative radiosensitivity of the remaining tumors would be gained if all of the small tumors were excluded from consideration. The result of such a procedure is shown in the bottom row. Now we find an orderly arrangement with those

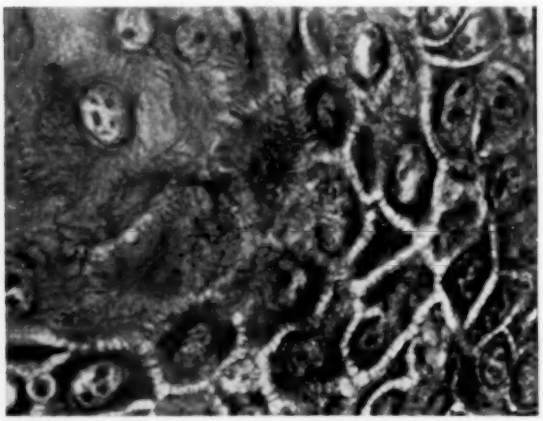

Fig. 3. Intercellular bridges. Photomicrograph of a squamous cell epithelioma of the anterior half of the tongue showing protoplasmic bridges between every cell. The intracellular fibrils shown in some of the cells are probably tonofibrils—Masson's trichrome stain. This tumor was small and was entirely destroyed by interstitial radium.

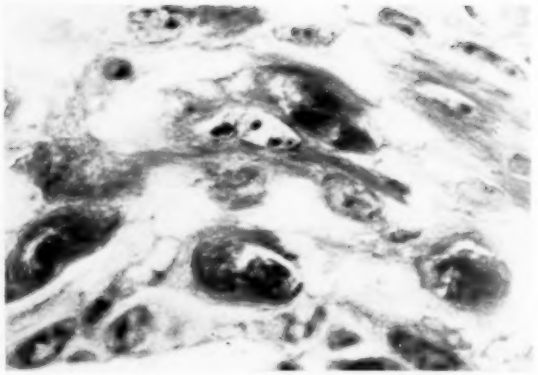

Fig. 2. Intracellular keratin. Photomicrograph of a squamous cell epithelioma of the tonsil which showed rare pearls, few intercellular bridges, and very little extracellular keratin. With Masson's trichrome stain it was found that many tumor cells were laden with closely packed strands of brilliantly red staining keratin. In the photograph this material is very dark and almost fills the cytoplasm about the nucleus. The tumor was markedly resistant.

tumors with the greatest quantity of keratin, intercellular bridges or pearls, showing the highest percentage of resistant cases and, with lessening quantities, the resistance decreases until, with absence of these three factors, almost all the tumors are sensitive. Of the three factors, the amount of keratin in the tumor as determined by the trichrome stain has seemed the most reliable single factor. However, it is wise to use all three in making estimations. Estimations should be made from tumor tissue beneath, rather than at the surface, since this will represent the condition of the bulk of the tumor tissue. One should remember also that the metastases do not always show the same degree of differentiation as does the parent tumor—it may be either greater or less.

Stratification, or differentiation into layers, has seemed to me to be so difficult of estimation as to be an unreliable criterion. Usually it is an indication of differentiation and, when present, means a resistant tumor.

SUMMARY

An estimation of radiosensitivity of oral, nasal and laryngeal neoplasms necessitates

the consideration of numerous factors both extrinsic and intrinsic. This investigation has shown that infection, invasion of bone and cartilage, deep infiltration and syphilis tended to make this group of cancers statistically somewhat more resistant than the absence of these features. Small size and the presence of leucoplakia favored statistical radiosensitivity. There was marked variation according to anatomical site: vocal cord, nasal, antral, cheek and gum tumors included a high percentage of resistant tumors and extrinsic laryngeal, nasopharyngeal, tongue, floor of mouth and lower lip tumors included a high percentage of sensitive neoplasms.

The microscopic features which seemed to have the greatest significance were: (*a*) As indications of resistance: secretion of mucin, nerve sheath invasion, calcification, formation of glands, melanin, collagen fibers (in the fibrosarcoma), and other adult structures; and, in the squamous cell epitheliomas, the presence of much keratin, many intercellular bridges and many pearls. (*b*) As indications of sensitivity: lympho-epitheliomas, lymphosarcomas and, in the squamous cell epitheliomas, the complete or relative absence of keratin, pearls and intercellular bridges.

The features studied which seemed to have little or no importance as indicators of relative radiosensitivity were: the presence or absence of metastases, papillary tumors, bizarre cells, and mitoses. The presence or absence of stratification is too difficult to recognize to warrant its use as an indicator.*

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* For discussion, see page 337.

HISTOLOGIC STRUCTURE OF CARCINOMA OF THE CERVIX UTERI AND ITS RELATION TO RADIOSENSITIVITY*

By CHARLES C. NORRIS, M.D.
PHILADELPHIA, PENNSYLVANIA

SINCE the advent of irradiation, the pathology of tumors has undergone marked modification. New classifications have been advanced, and the degrees of anaplasia have received special attention. Formerly, the histologic diagnosis of carcinoma, sarcoma, or any form of malignant growth was an indication to the surgeon that excision over as wide an area as was feasible was to be performed. At the present day the determination of the mode of treatment rests largely on the pathologic diagnosis, and the ultimate prognosis of the individual case is often dependent upon the pathologist's findings.

The term radiosensitivity, as applied to neoplasms, may be defined as that characteristic of a tumor which permits it to be altered or destroyed by the effects of irradiation—usually either radium or roentgen rays. Radiosensitivity is a relative term, since all varieties of neoplastic tissue can be destroyed by irradiation provided the radiotherapy is sufficiently intense. In this connection it may be mentioned that what was regarded as intensive irradiation some years ago, would hardly, with our present improved methods and more powerful machines, be considered so today.

Various criteria have been suggested by which the degree of radiosensitivity and radioresistance may be judged. Chief among these are local healing, the proportion of cures, the effect of the treatment upon neoplastic tissue in culture. At this point it may be advisable to emphasize the marked difference between primary regression and total destruction. Primary regression, as evidenced by complete epidermidalization and apparent clinical disappearance of the neoplasm, occurs at some time in about 60 to 75 per cent of cases of cervical carcinoma, whereas five year cures are secured in only about 25 to 30 per cent of cases. Generally speaking, markedly radiosensitive tumors disappear rapidly, but their recurrence is correspondingly rapid and early death ensues. The reverse is true of the radioresistant group. The Grade III epidermoid tumors also apparently give rise to earlier metastases, although this finding is not borne out by the results obtained by Healy and Cutler.[10]

Stewart[22] defines radiosensitivity "as that combination of circumstances resident in the tumor of the host which permits marked or local tumor regression under doses of radiation sufficiently small to preserve the essential integrity of the host's tissue."

From a practical standpoint, radiosensitive tumors may be classed as those which are more satisfactorily treated by irradiation than by surgery. This statement is by no means either a uniformly accurate, or a scientific definition of radiosensitivity. It has, however, much to recommend it from a practical standpoint, but many exceptions make such a standard far from ideal. To mention only one of these is the location of the tumor. This in itself is often the deciding factor as to whether surgery or irradiation is the method to be employed.

In the past there has been some question as to whether irradiation destroyed carcinoma by a direct action upon the carcinoma cell, or whether the destruction resulted from other causes, as, for example, the production of fibrous tissue resulting in avascularization of the neoplasm. Considerable research work upon this point appears to demonstrate that the destruction of carcinoma by irradiation is due to a di-

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rect action, and that although other elements enter into the problem, this so-called selective action is the chief factor—an opinion with which I concur.

Wood[23] maintains that "the action of radiation is in all probability due to the secondary effect of free electrons released by the action of the rays on the atomic structures of the tissues," and that "the effect on the individual cell is independent of the wave length." As early as 1906 Bergonié and Tribondeau[1] observed that immature cells and cells in an active state of division were more radiosensitive than those cells that had already acquired their fixed adult morphologic and physiologic characteristics.

Since that time nearly all observers have remarked upon the radiosensitivity of embryonal tissue. Probably all the constituents of young cells—cell membrane, cytoplasm, nuclear membrane and nucleus—are more delicate and the membranes thinner and more fragile than in adult cells. It is probable that such cells possess a higher metabolic rate. Ewing[7] believes that both nucleus and cytoplasm are affected in varying degrees. Stewart,[22] and Regaud and Lacassagne[19] are of the opinion that the nucleus is the vulnerable portion of the cell. Histologic examination of recently irradiated tissue and the microdissection work of biologists would seem to confirm the latter view. However, Packard[15] calls attention to the fact that although it is possible to detect alterations in some parts of the cell before others this is no absolute proof that the former parts are primarily affected. He also asserts that research has demonstrated that one cell which, after exposure, appears to be moribund may recover, and that another which looks normal after exposure may die later.

The study of radiosensitivity is a complicated one, owing to the fact that so many factors enter either directly or indirectly into the question. Among these may be mentioned the location of the tumor, its accessibility, the character of its bed, the distance, and the type of intervening tissues; whether the neoplasm is papillary or infiltrating; the character of its blood supply; whether the blood vesssels possess thick or thin walls, their situation, whether central or peripheral, the general vascularity of the new growth, the size and perhaps the shape of the neoplasm, the character of the tumor cells, the degree of maturity, the proportion of immature cells, the relative number of cells undergoing mitosis, the amount of adipose tissue present, the rapidity of growth of the tumor, the relative amount of fibrous tissue, and the desmoplastic property of the neoplasm; whether or not there has been previous irradiation, the presence of infection, the general condition of the patient, her age, the presence of syphilis, tuberculosis, or trauma caused by earlier operative procedure, the degree of anemia, cachexia, or ischemia, hereditary influence of the tissue from which the tumor had its origin, the presence of metastases and perhaps even the social status of the patient. It has been asserted that the red-blonde type of patient who exhibits inadequate pigment to protect her skin from sunlight responds poorly to irradiation. Intensity of irradiation, dosage, distance, filter, duration of exposure, and perhaps other factors also enter into the problem. It is apparent, therefore, that the entire subject of radiosensitivity of tumors is so complex and is influenced by so many factors that positive conclusions regarding individual cases are difficult of attainment, and even generalizations often require qualifying statements. To mention but one example, it is generally conceded that the degree of anaplasia and the amount of mitosis are definite factors in producing radiosensitivity, and yet it is well known that both may vary markedly in different sections of the same tumor.

This is true of cervical carcinoma, as well as of many other malignant neoplasms. I have recently observed, in a case of cervical carcinoma removed by operation, that the periphery contained an enormous number of cells undergoing mitosis, whereas

there were practically none in the center of the tumor. This is true also of the proportion of embryonal cells; thus one area —usually at the advancing edge—may be largely anaplastic whereas another section, taken from a different location, will present a picture of a fairly well-differentiated tumor. When cervical carcinoma is treated by radium, usually only a single and often but a small bit of tissue is available for study; hence the grading of the tumor by histologic examination becomes even more uncertain. When considered in large groups, I believe that a certain amount of dependence may be placed upon histologic grading, but when applied to individual cases this becomes extremely uncertain. To further complicate the histologic grading and radiosensitivity, the cellular structure of neoplasms probably undergoes alteration during the different stages of advancement of the growth, a fact that has been pointed out by Meyer,[14] and has frequently been observed in our own laboratory. Wood[23] states that while one tumor may be sensitive, another neoplasm of exactly the same morphology may be resistant, a condition that is certainly not infrequently observed, and with the present methods of examination that are available, is unexplainable.

In general, papillary tumors are more sensitive than are those of the infiltrating type.

Among a group of 128 cases, the following results were observed:

Table I

Clinical Type of Growth	Number of Cases	Per Cent of Five Year Cures
Papillary	19	31.5
Infiltrating	109	12.8

It is probable that the type of circulation is an important factor in determining radiosensitivity. Neoplasms that are soft, friable, highly vascular, and of the so-called papillary or cauliflower type usually undergo marked primary regression, and disappear rapidly under suitable irradiation. This is particularly true of those growths that are situated upon the portio. Hard, infiltrating tumors within the canal seem to be much more resistant. Increased cellularity, anaplasia, and mitosis enhance the sensitivity. Jolly[11] has shown that vasoligation prior to irradiation decreased the sensitivity. Markedly anemic, or cachectic patients, undoubtedly respond poorly to irradiation. Borak[3] asserts that the inherent radiosensitivity of the parent tissue from which the tumor springs has perhaps the greatest influence upon its radiosensitivity. He believes that the radiosensitivity can never be lower than, but must always be the same as or higher than, that of the parent tissue. High metabolism of the tumor cells is an important factor in radiosensitivity, and in the cervix this is nearly always synonymous with rapid growth. Ewing[8] states that "probably the most important factor which renders tumors resistant is the desmoplastic property or tendency to produce growth of connective tissue." Blau[2] believes that cervical carcinomas are all so radiosensitive as to be second only to skin chancroid. Regaud[18] is of the opinion that tumors which recur after radiation therapy are more resistant than the primary lesions were. Burnam[5] believes that Bright's disease, diabetes, hyperthyroidism, and especially syphilis are complications that tend to result in undue reaction of the tissues to irradiation, and that the dosage should be considerably reduced when treating patients suffering from these diseases. A study of the literature shows a somewhat marked diversity of opinion regarding many points pertaining to the radiosensitivity of cervical carcinoma. As has been pointed out by Döderlein[6] and Stewart,[22] much of this disagreement seems to be due to the different methods of reporting their cases used by the various observers and to the divergent interpretations of the histologic pictures. Thus, what is classified as a highly embryonal tumor in one laboratory, may be differently classified in another. In order accurately to compare the results all the factors governing radiosensitivity must be the

same. Thus, the tumors must all be of the same size, occupy the same situations, be of the same histologic type, contain the same or relatively the same number of mitotic figures, and must receive the same treatment so far as irradiation is concerned. As has been pointed out by Heyman, even when this is done a relatively large series of cases is necessarily split up into groups that are often too small to permit accurate conclusions to be drawn from them. Furthermore, a study of cervical carcinoma seems to show that, compared with certain other forms of tumor, all are relatively embryonal in type, a fact that still further enhances the difficulty of such a study.

An extensive nomenclature regarding radiosensitivity has been amassed. As early as 1904 Perthes[16] observed that there was greater sensitivity of the cells at the time of nuclear division. In 1923 Martzloff[13] classified a series of cases of carcinoma of the cervix according to a histologic index: for example, spinal cell, transitional, and spindle cell epitheliomas (Grades I, II, and III). Martzloff's observations were confirmed by Broders[4] in 1925. In 1927, Fluhmann[9] recommended the classification of Schottländer and Kermauner[21] using the terms ripe, midripe, and unripe. In 1928, Healy and Cutler[10] suggested the terms adult, plexiform, and anaplastic, corresponding to Grades I, II, and III of Martzloff. In 1928, Schmitz and Hueper[20] realizing that many factors entered into the question, devised an elaborate system of classification which embodied some twenty criteria. Other terms, such as prickle or squamous, round or transitional cell, and basal cell, have also been employed.

Regaud,[17] as early as 1922, called attention to the relative radioresistance of the adenocarcinomas, an observation that has received general confirmation.

Adenocarcinoma of the cervix constitutes about 5 per cent of all cervical carcinomas. For years these growths were regarded as an unfavorable type for operation, and a study of the statistics of irradiated cases shows that, while they are perhaps somewhat more resistant to this form of treatment than are some of the more embryonal types, the results from irradiation are quite as good as, if not better than, those secured by operation. In our own small group of cases the results of irradiation have been superior to those secured in the epidermoid carcinomas, both as to local healing and as to five year salvage. Taking local healing alone as a basis of radiosensitivity, Kimbrough and Norris[12] found according to Martzloff's classification:

TABLE II

Grade	Number of Cases	Complete Local Healing in 3 Months
		per cent
I Ripe epidermoid	70	54.3
II Midripe epidermoid	29	41.3
III Unripe epidermoid	19	57.9
Adenocarcinoma	7	57.0

Analyzed from the standpoint of five year salvage the same series of cases showed:

TABLE III

Grade	Per Cent of Five Year Salvage
I Ripe epidermoid	28.0
II Midripe epidermoid	25.0
III Unripe Epidermoid	20.0
Adenocarcinoma	42.8

These results are inconclusive.

In an effort to throw some light upon this subject, two groups of 10 cases each were submitted to a somewhat intensive study from the basis of the degree of maturity of the predominating cells composing the tumor and the number of mitotic figures which were present.

Group I was composed of cases in Stage I (Schmitz' classification), all of whom died of carcinoma within one year of the time of treatment. Group II was composed of cases all of whom were in Stage III (Schmitz' classification), and who all survived for five years. All the cases in both groups were treated in the same manner and with

essentially the same radiation dosage. Although these groups are necessarily small, they have been carefully studied and impartially selected, and if histologic grading in relationship to radiosensitivity were a well-defined guide, they should show a quite marked difference.

Studied from the standpoint of maturity of the predominating type of cell, the following results were secured:

TABLE IV

Histologic Type	Group I All Stage I—All Dead in 1 Year	Group II All Stage III—All Alive 5 Years
	No. of Cases	No. of Cases
Ripe	2	2
Midripe	2	3
Unripe	6	5

If this grading is correct, there is a difference of only 10 per cent in the two groups, the dead group containing one case more of the unripe type than the alive group, and one case less of the midripe type, the ripe type containing the same number of cases in each group.

Mitosis as an Index of Radiosensitivity. Studied from this standpoint, the two groups show the following:

TABLE V

	Mitotic Figures per 100 Oil-Immersion Fields				
		Counts			
	Average Number	Two Lowest		Two Highest	
Group I (Dead)	31	4	7	45	82
Group II (Alive)	56	12	17	92	164

Evans has devised an ingenious method for estimating the number of mitotic figures in one cubic millimeter of tumor tissue.*

* Diameter of oil immersion field—0.170 mm.; radius—0.085 mm.; area of one field (3.1416 times the square of the radius) 0.022698 square mm. Taking the average thickness of section as 0.011 mm. the cubic contents of one microscopic field would be 0.000249678 c.mm. or approximately 0.00025 c.mm., or 1/4,000 of a c.mm. Therefore having determined the number of mitotic figures in 100 fields, the number in a cubic millimeter would be 4,000 times the average number in one field, or 40 times the number in 100 fields

TABLE VI

	Mitotic Figures per Cubic Centimeter of Tumor Tissue				
		Counts			
	Average Number	Two Lowest		Two Highest	
Group I (Dead)	1,236	160	280	1,800	3,280
Group II (Alive)	2,224	480	680	3,680	6,560

The average number of mitotic figures per cubic centimeter of tumor tissue was nearly twice as large in the alive group as in the dead group. Comparison of individual cases, however, shows that there is a definite overlapping. Thus the two lowest counts of mitotic figures per cubic centimeter of tumor tissue in the dead group were 160 and 280 and the highest counts 1,800 and 3,280, whereas in the alive group the lowest counts were 480 and 680 and the highest counts 3,680 and 6,560.

An effort was made to study the different types of mitotic figures, but the final groups were too small on which to place dependence. It seemed, however, that when the three-armed and star-burst types were numerous, a high degree of malignancy was present.

CONCLUSIONS

1. All cervical carcinomas are quite radiosensitive.

2. As compared to many other tumors, the difference in sensitivity between the most radiosensitive types of carcinoma of the cervix and the most radioresistant is relatively slight.

3. The fact that the final salvage is small is due not to radioresistance on the part of the tumor, but to the difficulty of securing intensive diffuse irradiation of the entire growth, including the metastases.

4. As compared to many other tumors, all cervical carcinomas are relatively highly malignant.

5. In cervical carcinoma the radiosensitivity and the malignancy index tend to run more or less parallel.

6. The greater malignancy probably counterbalances the greater radiosensitiv-

ity and in part accounts for the relatively slight differences in the five year salvage of the different types.

7. As the normal cervical tissue is capable of withstanding extremely intensive irradiation, and taking into account the relatively high malignancy of all cervical carcinomas, our aim should be to apply as intensive and as diffuse irradiation as possible to all except definitely hopeless cases.

8. Histologic examination is neither a very practical nor a reliable guide as to either the prognosis or the radiation dosage. It may be of some use in groups, but means little in the individual case.

9. Papillary tumors are generally more radiosensitive than are those of the infiltrating type.

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DISCUSSION OF SYMPOSIUM ON RADIUM DOSAGE AND TECHNIQUE*

(Physical and Biologic Factors)

Dr. Francis Carter Wood, New York City. It is impossible to discuss all the papers individually, but I should like to say that my impression of this meeting is very different from meetings of five or ten years ago, in that this is an "observational" meeting. We have

* Papers of Glasser, Stenstrom, Weatherwax, Quimby, Packard, Lenz and Freid, Stout, and Norris.

ceased to talk about patients being improved and so on, and are putting down actual observed figures of patients dead and alive, with careful morphological study of the tissues and individual irradiation of patients, not treated en masse but according to their condition.

The paper of Dr. Lenz and Dr. Freid called attention to the danger of treating patients with general disease, particularly diabetes. Syphilis of the tongue or mouth is a contraindication for irradiation, for while the tumor may disappear the patient's tongue may also, at a later date, almost entirely ulcerate out. We have all seen these patients who are always prohibitive as to therapy. All this means prolonged study of the case, the employment of biopsy as an estimation of dosage, and all this tends to make treatment of malignancy by radiation a much more exact science than heretofore.

I am glad to see that there is more general agreement as to dosage. As a matter of fact, the radium pack will probably be replaced by the roentgen ray, and for interstitital irradiation we will use carefully measured highly filtered quantities of element.

There is one point which is important, and that is that radiation therapy should only be employed by those with sufficient clinical experience in the handling of the material. We now realize that it is impossible to treat patients effectively and properly with moderate doses of radiation. We have learned from the treatment of carcinoma of the cervix that very large doses should be used. Owing to its situation, surrounded by heavy muscular walls and being partially an external site it has been possible to treat the disease with enormous doses and the fine results obtained in carcinoma of the cervix have pointed the direction for other lesions and methods.

The general use of the Coutard method has demonstrated the necessity for the cooperation of our surgical colleagues. The severe skin injuries which are produced as a necessary part of the Coutard treatment require surgical care, and facilities for that surgical care should be offered to the radiologist who is employing this method. Any criticism of the severity of the tissue damage by the surgeon is out of place, for results are being obtained with this procedure on inoperable neoplasms, and certainly the injuries are no more difficult for the patient to bear than some of those produced by extensive surgery. However, the whole situation between the radiotherapist and the surgeon is improving, and there is a great deal more cooperation between the two aspects of cancer therapy than there was five years ago. The relative value of the two methods in a given type of neoplasm will only be finally settled by the kind of work which has been reported this morning and in which the same type of statistical accuracy is applied to the material under observation that the surgeon applies to his.

Dr. J. E. Gendreau, Montreal. These papers have been very interesting and instructive, and the physical measurements in the curie therapy are very important. We have no agreement on units. We have seen that the roentgen equivalent in milligram-hours, or the roentgen equivalent in r is not fixed, and we must wait until at least the Zurich meeting where this will be discussed to have a better agreement. The biological way is theoretically a better way of measuring, but we have no biologic units. The threshold erythema dose is a wonderful method and we must, I think, use the milligram-hours, but we must add the word "distance." In many reports we have, they say, only 1,300 mg-hr. without stating the distance. We must also bring in the quality and the filtration. We have seen in many papers today that this question is not settled but it is influencing the dosage. The physical wave length, the physical quality is something to be considered. Clinically it is the common consensus that the quality has something to do and we must consider the quality. Also, the filter. There is not much advantage in some ways but clinically there is much difference, and keeping the heavy copper filter and the association of dosage is important.

The paper of Dr. Weatherwax is very important. We have seen papers stating that very heavy dosage must be given in the tumor, and this is where the dosage is important. We cannot do that now with our radium units but we can with our roentgen dosage in many instances. To combine these dosages we must use physical methods and these will enable us to give more than the interstitial therapy. The interstitital methods are losing favor, I think, for the elements are hard to establish, the homogeneity is hard to establish, and the interstitial method is also bringing in trauma, so we must rely more upon external dosage.

That external dosage cannot be given without heavy filtration, long distance and high voltages, but with this external dosage being improved we can diminish the interstitial dosage which is less advisable.

If we come to the special quality of the short wave, Dr. Weatherwax brought a reflection on the roentgen ray. A new idea is, too, that the recently discovered radioactivity produced by rays explains why short waves will have more result, because artificial radioactivity is produced in this way, and they do not come only from the electrons but from the very nucleus. Then we can have by physical ideas an explanation of the old clinical idea that we have an action due to quality. I do not rely much upon physics to settle the problem now. Physics has brought to us may things that were unexplained but that were later explained.

The microscopic structure has been well studied. It recalled the idea of Regaud that the time factor is brought in on account of those periods in which the cells are active, and the double activity, regeneration, mitosis reproduction, sensitive state and insensitive state, the production of mucin, keratin and all those factors that diminish the sensitivity of the cell that is reproduced. Trying to find this has increased the time of treatment by many days and many weeks. Hence, the time factor is a clinical factor as well as a physical factor.

Dr. George E. Pfahler, Philadelphia. I am very much impressed by these papers this morning, and we certainly must conclude that irradiation is no longer a matter of the mysterious use of a bit of radium. The quality of filtration, the use of distance and the distribution of the radium have all been shown to have a very important influence on the results, and every one of these points must be taken into consideration in relation to the clinical problem that is present.

We heard Dr. Lenz and Dr. Freid discuss the matter of the degenerative diseases in relation to the use of radium. We must not briefly and bluntly conclude that it is the radium added to the disease, but when we add radium to a disease we are adding on additional strain to that patient, such as sending a heart patient up to the top of a mountain or something of that type. That fear may sometimes prevent these patients from getting the benefits they would have, but extraordinary care must be taken, especially with regard to the extra strain on the patients.

With regard to the radiosensitivity, I have been much impressed with the papers presented and with others published indicating that the microscope will tell one almost at once whether he can get a patient well or not. I have not had that experience, and I think if we will treat the patient from the standpoint of the things we can determine by careful clinical examination we can get as many well as with other methods. We should try to give these patients all the radiation we believe the tissues will stand.

With regard to high filtration or no filtration, I am one who believes that the higher filtrations will give proportionately better results, with less damage to the other tissues.

THE VALUE OF ROENTGEN RAYS IN THE DIAGNOSIS AND SURGICAL TREATMENT OF EXTRAPULMONARY INTRATHORACIC TUMORS*

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I AM pleased to have the opportunity to present the subject of the value of roentgen rays in the diagnosis and surgical treatment of extrapulmonary intrathoracic tumors before the American Roentgen Ray Society because roentgenography plays such an important rôle in the recognition and differential diagnosis of these growths and surgical treatment offers the greatest hope for complete eradication of the disease. The clinical manifestations of these tumors are often meager and rarely pathognomonic, although they are always of great value when correlated with the roentgenologic findings in establishing a final diagnosis and in determining the type of treatment to be instituted. There are often many difficult problems associated with the establishment of an accurate diagnosis and in the selection of the most effective method of treatment of these growths. These problems are best solved by close cooperation between the roentgenologist, clinician, and surgeon. We have found that the best results are obtained by personal conferences to study the problems presented in each individual case.

The occurrence of these growths was known for many years before the advent of the roentgen ray, although their recognition on clinical symptoms and physical findings was as a rule attained so late in the course of the disease that surgical treatment was seldom possible and rarely successful. The older view was that most of these tumors were malignant. Such studies were based on long standing cases and on material at necropsy. The use of roentgen rays has made it possible to recognize these tumors earlier, before they have made serious inroads on the patient's general health, and has been one of the most important factors in making surgical treatment possible with the view of complete removal of such growths. A study of these early cases has proved that a relatively high percentage of the lesions are benign.

My experience in the surgical treatment of intrathoracic lesions consists of 47 cases in which such growths were removed at operation; 19 of the tumors were malignant and 28 were benign. I believe that all of these tumors are potentially malignant, and that the relatively high percentage of benign growths in this series is due to their removal before they had undergone malignant change. Such early removal was made possible chiefly because of roentgenologic recognition of the tumors, as some of them produced practically no localizing subjective symptoms but were found during the course of general examination and visualized during roentgenologic examination of the thorax. In some of these cases there were so few symptoms and physical findings that surgical intervention would not have been justified without visualization and substantiation of the intrathoracic tumor by the roentgenogram.

As valuable as roentgen rays are in the diagnosis of these lesions, it is not always possible to make a definite diagnosis of the type of growth after utilizing all of the roentgenologic methods now employed, and in many instances it is impossible to differentiate benign and malignant lesions. It is of interest to note that in the earlier cases seen at the Clinic the diagnosis almost invariably was of malignant tumor. As these tumors were operated on and the true nature of the growth was established, roentgenologic interpretation has gradu-

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

ally changed, and I believe in time it will approximate the high degree of accuracy in this field that it enjoys in other forms of disease, such as that of the stomach and gallbladder. In this way surgery is of considerable aid in roentgenologic diagnosis, as it is only by the definite knowledge that is established on microscopic examination of tumors removed by early operation that true interpretation of the roentgenologic findings can be accomplished.

Marked improvements are constantly being made in the methods of roentgenologic examination. I shall not attempt to go into the details of the techniques of these methods except to mention them in a general way. The single roentgenogram is of little value in the surgical consideration of these tumors, as it determines only the presence of the tumor and its position in the thorax in one plane. Anteroposterior and lateral stereoroentgenograms are of the greatest aid in determining not only the situation of the tumor in the thorax, but also the relation of surrounding normal structures to the tumor and any encroachment that the tumor has made on these structures. Anteroposterior stereoroentgenograms are more accurate in determining the relation of the tumor in the vertical plane of the thorax, and the lateral films are more accurate in determining the relation of the tumor to the anterior and posterior thoracic walls. Roentgenoscopic examination does not present the detail these stereoroentgenograms do, but it is of great value in determining the normal functional activity of intrathoracic structures and any impairment of these structures which may have been caused by the tumor. It is especially important in the differential diagnosis of aneurysm, particularly from anterior mediastinal tumors. Here the differential diagnosis is often made difficult by the adherence of dermoid cysts and teratoid tumors to the pericardium and great vessels, which causes a transmitted pulsation. Oblique roentgenograms are of value in selected cases, particularly in the differentiation and localization of esophageal lesions and tumors of the anterior thoracic wall and sternum. Horizontal roentgenograms are also of value in selected cases; they are taken in different positions to determine fluid level within the pleural cavity or within the walls of a cystic tumor.

In many cases the diagnosis is still obscure even after roentgenoscopic examination and the taking of an entire series of roentgenograms in different positions. In some of these cases additional information can be obtained by taking another series of roentgenograms after the production of artificial pneumothorax, or after the introduction of barium into the esophagus and, in some instances, of iodized oil into the bronchial tree. It is important that the same technical methods, particularly as to the distance of the patient from the film, be used in cases in which patients are being kept under observation or treatment, so that any change in the size of the roentgen shadows will be due to variation in the size of the lesion and not to variation in technique.

Radiation therapy is often of great aid in the differential diagnosis of radiosensitive tumors. This is of particular importance in the selection of cases for surgical intervention, as one of the most important lesions to rule out is mediastinal lymphoblastoma. These growths are not amenable to surgical treatment, and in the roentgenograms they can simulate the appearance of practically any other primary intrathoracic growth. A definite diagnosis of lymphoblastoma can often be made by complete roentgenologic study. In cases in which there is any doubt, roentgen therapy should be utilized, as these tumors are radiosensitive and will rapidly diminish in size and practically disappear in a relatively short period of time. Some diminution in the size of the roentgenologic shadow of the growth will be noted in three to five days after the initial treatment.

The roentgenologic and clinical findings in the 47 cases of intrathoracic tumor in which I removed the growth at opera-

tion briefly were as follows: Fifteen of these growths were considered to have originated from the spinal root or intercostal nerve sheaths and were grouped under the general term, perineural fibroblastoma. Thirteen of the tumors were benign and 2 were malignant. Eleven were classified pathologically as neurofibromas, 2 as cellular fibromas, and 2 as fibrosarcomas, which probably were benign tumors originally but had undergone malignant change. Thirteen of these growths were situated in the posterior mediastinum; 1 was situated in the posterior mediastinum and spinal cord, of the type often called a dumb-bell or hour-glass tumor, and 1 was situated in the lateral wall of the thorax. In this series these growths were the most common ones to be situated in the posterior mediastinum.

When these growths are benign, they are the most silent tumors within the thorax. The outstanding clinical features are the relatively few and mild symptoms which are associated with such large intrathoracic benign growths. When these growths undergo malignant change, however, the symptoms become very severe, particularly pain which is the most important subjective symptom in differentiating benign and malignant growths. The pain of malignant lesions becomes very marked, usually being most severe at night, and it often requires sedatives for relief. With benign lesions the pain is rarely severe, and the growths may attain enormous size without producing severe symptoms other than dyspnea. Dyspnea and other clinical manifestations are usually more marked when the tumor is situated in the upper part of the posterior mediastinum, because in this region the growth not only produces pressure on the lung itself, but in many instances it causes direct pressure on the large bronchi and hilus of the lung; at times, also, it exerts pressure on the trachea, causing marked interference with respiration, particularly on exertion. With this latter condition there is often an associated compression of the esophagus that causes some difficulty in swallowing. These complications can be recognized roentgenologically by introduction of iodized oil into the bronchial tree, in cases of bronchial obstruction, and by the introduction of barium into the esophagus, in cases of esophageal obstruction.

In the 4 cases in this group in which the tumor was benign the growth was found during the course of the general examination, and roentgenologic examination of the thorax was of paramount importance in establishing the diagnosis. The most common roentgenologic manifestation of these tumors is a circumscribed shadow, rounded in contour and with a sharp border, situated in the posterior mediastinum. Sometimes the tumor may be lobulated, but the borders are practically always sharply outlined. In some cases these tumors produce pressure erosion of the adjacent ribs, and in those cases in which the tumor arises within the intervertebral foramen, or spinal cord, definite roentgenologic signs in the vertebra are present, which have been described by Camp. The bone is eroded by direct pressure at the site of the tumor. The pedicles and laminae of the vertebra on the affected side are eroded and may be completely destroyed. There is enlargement of the intervertebral foramen and as the tumor enlarges in the posterior mediastinum, sufficient pressure may be exerted to produce widening of the intercostal spaces and erosion of the adjacent ribs.

All of these changes were noted in the case of the one dumb-bell-shaped neurofibroma of the spinal cord and posterior mediastinum in this group. In two other cases in the group there was pressure erosion of the ribs. With one of the malignant lesions there was widening of the intercostal spaces and some erosion and destruction of the ribs, which was of the infiltrative nature that is characteristic of a malignant lesion. Erosion in such cases is a proliferative and infiltrative type of bone destruction, whereas with benign lesions the erosion is that due to pressure and is of the atrophic type. The lesion most commonly to be considered

in the differential diagnosis of this group of tumors is aneurysm of the arch or descending portion of the aorta; this lesion can usually be differentiated by clinical manifestations and by roentgenoscopic examination of the thorax, which shows an expansile tumor. Sarcoma originating from the vertebrae or ribs can usually be differentiated because of the more extreme pain and the infiltrating destructive type of erosion of the involved ribs and vertebrae. Endotheliomas originating in the posterior mediastinum in early cases may be difficult to differentiate from neurofibromas, as endotheliomas are practically symptomless. In the later cases, however, the differential diagnosis is not difficult because these lesions usually present the clinical manifestations of a malignant growth, such as bloody pleural effusion and irregular outline of the tumor as shown roentgenologically. In one early case of endothelioma in this series in which the tumor was discovered accidentally during the course of a general examination, the preoperative roentgenological diagnosis of neurofibroma was made. I have had one case recently in which the tumor filled the entire left portion of the thorax, and pushed the heart entirely to the right; after complete roentgenologic study, the diagnosis of pleural effusion was made. Diagnostic aspiration was done in this case which revealed a definite mass in the pleural cavity; there was no pleural effusion. Further roentgenologic studies were made and a tentative diagnosis of intrathoracic tumor was arrived at. At the time of operation, a huge benign neurofibromyoma was found which had caused complete compression of all but a small part of the apex of the lung. Pleural effusion may be associated with any of these tumors, although it is not common. In one case in this group there was a bloody pleural effusion associated with a benign tumor. The tumor could not be demonstrated until a roentgenogram was taken immediately after removal of the pleural effusion. This emphasizes the importance of always considering the possibility of a tumor being the cause of a pleural effusion, as well as the possibility of a benign tumor being associated with a blood effusion.

The tumors in 12 cases in this series were classified pathologically under the general term, teratoma. Five were classified as dermoid cysts because their structure consisted essentially of ectoderm, and in 5 others the tissue elements were derived from all three of the germinal layers; in 1 of these latter growths the tissue elements had attained such a high degree of organoid structure that it was designated as a fetal parasite. The remaining 2 growths were malignant and were of the squamous cell epithelioma type. These I believe were primarily benign tumors that had undergone malignant change. In 11 of these cases the tumor originated in the anterior mediastinum; in 5 cases the tumor extended into the left thoracic cavity, in 4 into the right thoracic cavity, and in 1 into both right and left thoracic cavities. In 1 case the tumor was confined to the anterior and superior mediastinum and presented just above the suprasternal notch (the case in which it was designated a fetal parasite). In the remaining case the tumor apparently originated in the right side of the diaphragm, and it may have originated from cell occlusion with improper fusion of the septum transversum and pleuroperitoneal membrane at the time of closure of the diaphragm. In 11 cases the tumor was cystic; in the remaining case it was a solid tumor, which was the one designated as a fetal parasite. These tumors probably are of greater interest than any other type of tumor within the thorax because of their congenital origin and the varied symptoms, clinical course, and the difficulties which are often associated in establishing a diagnosis, either from clinical manifestations or roentgenologic findings. In my experience they are the most common type of tumor in the anterior mediastinum. The dermoid cysts have the distinction of being the only tumors within the thorax that may have a pathognomonic clinical symptom, which consists of the expectoration of hair; this

does not occur in all cases, however, and it is only present in some of the advanced cases in which the cyst has ruptured into the lung. The usual clinical course in these cases is essentially that of an inflammatory lesion, consisting of pain in the mediastinum and dyspnea, and with a sense of pressure, often associated with sore throat, which is commonly diagnosed clinically as pleurisy and pneumonia. Pain is a much more frequent symptom of these tumors than it is of posterior mediastinal tumors, due to the marked fixation of the growths to surrounding structures, the limited space in the anterior mediastinum in which they can expand, and their cystic character.

The roentgenologic manifestations of these growths are not as clear cut as those of other types of tumor, and, even after the most exhaustive roentgenologic study, a definite diagnosis cannot be established. Fortunately it is in this group that the clinical symptoms are often of great aid in assisting in determining the type of tumor present. I believe that one of the main reasons for the difficulty of establishing a definite roentgenologic diagnosis in these cases is due to the marked inflammatory reaction which is often present and which produces a change simulating an inflammatory or infiltrating type of lesion in the structures surrounding the growth, often obscuring the definite outline of the tumor. This is particularly true in cases in which the cysts have ruptured into the lung, producing a secondary inflammatory lesion in the lung that may entirely obscure the original lesion. The most common roentgenologic manifestation in the uncomplicated cases is a shadow in the anterior mediastinum; in my experience this is the most common benign tumor situated in this region. The growths usually originate in the anterior mediastinum in the region of the base of the great vessels and upper portion of the pericardium, to which they are very adherent and protrude into one or both thoracic cavities, becoming firmly adherent to the adjacent lung and thoracic wall. The outline of the tumor may be hazy and infiltrating in character when viewed in one plane, but may show a rounded contour when viewed in another. Some tumors, particularly those of the teratoid type, may be cystic, and a definite fluid level may be visualized with its surrounding sac. Roentgenoscopic examination of the thorax is very important in the diagnosis of these tumors, as most of the growths present a transmitted pulsation due to their attachment to the pericardium at the base of the great vessels, and great care must be exercised in differentiating these lesions and aneurysms of the arch or descending aorta. Radiotherapy as a therapeutic test is often of aid in establishing a diagnosis by ruling out the presence of lymphoblastoma, which is one of the most common tumors to be considered in the differential diagnosis. Other conditions to be considered in the differential diagnosis are thymoma, substernal goiter, and mediastinal abscess.

In 6 cases in this series the growths were classified pathologically as endothelioma. Three of these tumors originated in the parietal pleura, 1 in the visceral pleura, 1 in the anterior mediastinum, and 1 in the posterior mediastinum. The 3 originating in the parietal pleura presented palpable external tumors of varying sizes, the largest portion of the tumor being within the thoracic cavity. There is no distinctive roentgenologic manifestation of these growths and in no case was a definite diagnosis made by roentgen rays other than that of an intrathoracic tumor.[3] In 1 case in which the tumor presented in the anterior mediastinum, a tentative roentgenologic diagnosis of teratoma was made. In the case of the growth presenting in the posterior mediastinum, a definite diagnosis of neurofibroma was made. Because of the great variation in size and character of these growths, I do not believe that it is possible to establish a definite diagnosis in these cases. Roentgen rays have their greatest value in determining the extent and exact situation of the growths and in ruling out the complications that may contraindicate surgical intervention.

In 11 of the cases in this series tumors were classified pathologically as sarcoma. In 7 of these the tumor originated in the bony structures of the wall of the thorax, and in 4 of these 7 cases there was a palpable external tumor. In 7 cases the tumor presented in the posterior mediastinum and there was no palpable external tumor; in 4 of these the tumor originated in the rib, close to its attachment to the vertebra; in some cases there was also involvement of the vertebra. The roentgenologic findings of primary osteogenic sarcoma are quite definite and present the signs of dissolution and destruction of bone with secondary involvement of the surrounding soft tissues. These tumors have a very characteristic roentgenologic appearance, but they cannot always be distinguished from neurofibromas, as in 2 cases in this series in which the preoperative roentgenologic findings suggested neurofibroma. Tumors of this type should always be considered in the differential diagnosis. The clinical manifestations of these tumors are often of great aid in establishing a definite clinical diagnosis, as the outstanding symptom associated with sarcoma is pain; this pain is usually severe in type, at first being intermittent in character and later becoming more or less constant; it is often more noticeable at night. In cases in which a neurofibroma has undergone malignant change, it may be impossible to make a definite diagnosis on roentgenologic findings or clinical symptoms.

In 2 cases in this series the tumor was classified pathologically as chondroma and in one as chondro-osteoma. In these cases the entire chondroma was practically within the thorax and extensive transpleural operation was necessary to remove the growth. Roentgen rays were of value in these cases in determining the situation and extent of the tumor. One of the chondromas was discernible in the anterior portion of the thorax because of the marked calcification of the growth. In the other case a moderate-sized external mass presented in the anterior wall of the thorax, but the major portion of the tumor was in the thorax and filled practically two-thirds of the thoracic cavity with chondromyxomatous material which was definitely encapsulated. The chondro-osteoma involved one entire rib, from the sternum to the spine. It was beautifully visualized in the lateral roentgenogram, which revealed pressure erosion of the adjacent ribs; a roentgenologic diagnosis of a benign lesion was made.

Although roentgenologic studies of the thorax may be said to give the most important evidence in the clinical diagnosis of intrathoracic tumors, they are of even greater importance in those cases which are considered for surgical treatment, not only for their assistance in the selection of operable growths, but also because of their aid in determining the most accessible type of approach to the tumor as well as in determining the presence of conditions that might after operation become complications.

The most important considerations in the surgical treatment of intrathoracic new growths are early diagnosis and removal, preoperative preparation of the patient, selection of the most accessible method of approach, application of adequate mechanical means for maintaining intrapulmonary pressure, and postoperative care of the patient. The significance of early diagnosis of malignant growths is obvious. With benign growths it is important to institute surgical treatment before the tumor has encroached on important structures within the thorax, or before it has attained such great size that the operative risk is greatly increased. The immediate operative risk is often decreased by preliminary artificial pneumothorax, which permits the patient to become accustomed to the unilateral alteration of pulmonary pressure. This procedure cannot be carried out in those cases in which the lung is firmly adherent to the tumor or thoracic wall as the adhesions prevent the collapse of the lung by air pressure. However, when artificial pneumothorax can be accomplished,

it should be done three to five days prior to operation.

Much of the advancement that has been made in surgical removal of intrathoracic growths has been accomplished because of marked improvement in the administration of anesthetic agents. The greatest immediate danger in intrapleural operation is open pneumothorax with collapse of the lung. This may produce severe respiratory and circulatory disturbances which may result in sudden death. These dangers have been practically eliminated by the use of intratracheal anesthesia, induced by means of an apparatus by which gas and oxygen are administered under positive pressure. I prefer ethylene gas as the anesthetic agent; the administration of the anesthetic should be in the hands of a skilled anesthetist. In cases in which partial collapse of the lung is required, the lung should be permitted to expand fully every four to five minutes during the course of the operation. A suction pump should be applied to the intratracheal catheter, before it is withdrawn, to remove any mucus that may have accumulated in the trachea. It may be stated that the use of intratracheal, positive pressure anesthesia has been of the same relative importance to the technical problems associated with surgical removal of these growths as roentgen rays have been to the clinical diagnosis of the lesions.

The chief technical difficulties associated with surgical removal of these growths are as follows: (1) access is through the bony encasement of the thorax, and a method of approach must be selected that will give the greatest exposure of the tumor with the minimal amount of trauma to the thoracic viscera and thoracic wall; (2) traction on the important structures in the mediastinum, to which the tumor might be adherent, is an element of danger, and (3) complete reconstruction of the thoracic cage, so as to restore the normal relations of the thoracic viscera and to give the minimal amount of deformity, is advisable.

The method of approach to intrathoracic tumors depends on the situation of the growth and can only be determined after a thorough study of the complete roentgenologic manifestations of the growth. The importance of this cannot be overestimated, because it is only by careful preliminary planning of the operative procedure that the most suitable type of approach to the tumor can be made, and in determining this, that method should be selected that not only will give access to the tumor, but will lend itself to complete reconstruction of the thoracic cage. If the tumor is in the anterior or posterior mediastinum, I prefer to make a posterolateral incision between the vertebral border of the scapula and the spinal column, and laterally just below the angle of the scapula. The pleural cavity can be opened through the intercostal space, or through the internal layer of periosteum after partial resection of a rib; the position of the incision through the thoracic wall depends on the situation of the tumor. In selected cases of anterior mediastinal tumor, it may be advisable to use an anterior approach by splitting the sternum or by turning a flap of the anterior thoracic wall, but for most anterior mediastinal tumors, I prefer to use a posterolateral incision, because this type of incision lends itself to reconstruction of the thoracic cage much more readily than incisions through the anterior thoracic wall.

The type of operation depends to some extent on the lesion found and on the indications in each case. In most cases in which circumscribed tumors are entirely intrathoracic, it is best to remove them completely by transpleural operation in one stage. I have removed some posterior mediastinal tumors by extrapleural operation, but I have usually found the pleura so adherent to the tumor that the pleural cavity was ultimately opened in the course of removal of the growth, thus subjecting the patient to all of the dangers of transpleural operation as well as increasing the possibilities of pleural effusion from trauma due to wide dissection of the parietal pleura. In a few cases of anterior mediastinal tu-

mor in which I have operated through an anterior incision, it was necessary to split the sternum, and in others it was necessary to cut the clavicle; but, in most cases in which the tumor was entirely within the thoracic cage, I have used a posterior transpleural operation, deflating the lung during removal of the tumor. For posterior mediastinal and spinal cord tumors of the dumbbell or hour-glass type, I believe the best type of operative procedure is laminectomy with posterior mediastinotomy at the same time. While this is a rather extensive operative procedure at one sitting, when done in stages there is great danger of complications, particularly of hemorrhage arising which may interfere with or prevent complete removal of the tumor. When done in one stage, however, the tumor can be completely removed and hemorrhage can be controlled, as there is adequate exposure of both spine and mediastinum which is obtained through two separate incisions: one laminectomy, and one posterior mediastinotomy. Dr. Craig and I have recently reported a case of this type. In some cases in which new growths are close to, or involve, the diaphragm, it is necessary to remove a portion of the diaphragm with the tumor of the thoracic wall, and the defect in the thoracic wall can be repaired by utilizing the paralyzed diaphragm after phrenicotomy.

The mortality in these cases is not great considering the magnitude of the operation. In these 47 cases in which I performed the various types of procedure just summarized, there were 5 deaths. In 2 of these cases the growths were malignant, 1 being a malignant degeneration of a dermoid cyst, and in 3 cases the lesions were benign. The 3 benign lesions had been present over such a long period of time that they had produced serious complications, which were large factors in the inability of the patients to survive the necessary operative procedures.

Since it is often impossible to determine definitely the operability or the type of tumor by present methods of diagnosis, and since there is reason to believe that a benign tumor will undergo malignant change, I believe that in all cases of intrathoracic tumor exploration should be carried out unless there is clinical and roentgenologic evidence of a hopeless, inoperable condition.

SUMMARY AND CONCLUSIONS

1. Roentgen rays have made possible the early diagnosis of intrathoracic new growths.

2. The differential diagnosis and relation of these growths to the normal structures within the thorax often require exhaustive roentgenologic studies, including roentgenoscopic examinations and roentgenograms taken in different planes after the use of various radiopaque materials.

3. Radiation therapy can be utilized as a therapeutic test in the differential diagnosis of radiosensitive tumors.

4. The percentage of accuracy in the diagnosis of the various types of tumors by roentgen rays is gradually increasing. This is being greatly aided by surgical removal of these growths, which has made possible the microscopic study of these early lesions.

5. Before the advent of roentgen rays most of these tumors were thought to be malignant, based on studies at necropsy and of long-standing cases.

6. Recognition of these growths by roentgenologic studies has made possible their early surgical removal, and microscopic study of these growths has shown that a relatively high percentage are benign, although they are potentially malignant and may undergo malignant change.

7. Roentgenologic studies are of great value in the selection of cases for surgical treatment, and in these cases such studies are of great aid in determining the situation of the growth and the type of operative approach to be used.

8. Roentgen rays are of great importance in the postoperative care of these patients and in the management of postoperative conditions.

9. Surgical removal offers the only hope

for eradication of the disease, and it should be instituted early before complications have occurred which increase the hazards or influence the results of the operative procedure.

10. The operative risk is not great considering the magnitude of the operation, as in the 47 cases, in many of which the tumors were huge, filled one entire side of the thorax and extended into the opposite side, there were but 5 deaths. In these 5 cases in which the patients did not survive operation, surgical intervention was delayed until complications had occurred, and these complications played an important rôle in the inability of the patients to survive the operative procedures.

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DISCUSSION

Dr. W. A. Evans, Detroit, Mich. Such an excellent paper as that just given by Dr. Harrington always impresses me with the undesirability of small hospitals and the impracticability and futility of an effort to return the practice of medicine to the so-called family doctor. Rather, it is apparent that there is more and more need for greater concentration of the personnel, effort and equipment, to the end that every patient obtains the maximum in medicine as far as possible. And by this statement I mean to cast no reflection on the general practitioner, but simply to point out some of the limitations of such a plan.

I am willing to concede that Surgeon Harrington is more familiar with roentgen diagnosis of chest tumors than Roentgenologist Evans is with their surgical aspects. Dr. Harrington reflects his highly satisfactory roentgen environment. I have followed closely for years his efforts in the removal of thoracic tumors—I lieve his first report included 19 cases successfully operated upon—as I have followed Tudor Edwards, of England, and Graham and Singer, of St. Louis. My confrères of Detroit who are specializing in thoracic surgery, Dr. E. J. O'Brien and Dr. W. M. Tuttle, have had but little experience in surgical procedures for tumor, but they are thoroughly familiar with the difficulties and they both advise me that Dr. Harrington's results are truly remarkable.

Dr. Harrington has most thoroughly and satisfactorily credited the roentgen method as an aid in differential diagnosis of thoracic tumors, with the exception of the so-called therapeutic dose. His conclusions appear proper when applied to his clinic, but they would not be applicable in the practice of the average thoracic surgeon. His percentage of benign tumors is unusually high, for he has the advantage of a more or less selected group, but in our experience there is a larger percentage of malignancy and under these conditions we believe the active use of the therapeutic dose is highly advantageous.

In communities not blessed with the degree of surgical expertness manifested by Dr. Harrington, we strongly urge the method we have used, and that is the plan of exposing the tumor to the optimum dose of radiation. The technique involved in this varies with the capacity of the installation. With the 200 kv. installation, it is necessary to cross fire and in doing this one is limited by the sensitivity of the pulmonary tissues. In supervoltage installations the depth dose is sufficient, so that by exposures over both the anterior chest wall and the back the optimum depth dose can be given, with full protection offered the lung areas. Following such a therapeutic application of radiation, roentgenographic studies should be made to observe the effect on the tumor, and of course the rate of resolution determines the histological structure of the tumor.

One should not conclude that a slow rate of resolution means inability to control a tumor, for in one of our cases a large mediastinal mass required more than a year for satisfactory resolution. While no histological classification of this tumor could be made (and, by the way this is one advantage which the surgical method has), still it could be safely assumed that the condition was one of fibroma. The roentgen therapist should cooperate actively with the thoracic surgeon and at the proper time the patient should be referred for surgical treatment.

Dr. H. R. Decker, Pittsburgh, Pa. I wish to thank Dr. Harrington and members of the Society and the officers for the privilege of discussing this paper here this morning. We have had an extremely fine demonstration, I think, of this subject of intrathoracic tumors from the roentgen point of view and also from the surgical point of view. When Dr. Harrington speaks, the last word is said on this subject, for no one in this country has had a larger experience, I think you will agree with me from the figures that he has given us, or a more successful experience. He has shown conclusively how indispensable the roentgen examination is to a surgeon in dealing with this problem. Perhaps he has made, with the wonderful pictures he has displayed, the diagnosis seem a little too easy and simple. It seems to me that the rôle of the roentgen ray in this field is several fold. In the first place, there is a group of cases, unquestionably, that baffle diagnosis at all, on account of their clinical silence, until such time as pressure symptoms develop, and then he who runs may read. In this situation a roentgen picture simply confirms a situation that is already patent.

In the second group of cases, there is perhaps one symptom such as dyspnea or cough which cannot be explained in any other fashion, and in which a roentgenogram is taken and the diagnosis established by it.

Then, again, we have a group of cases in which it seems to me the roentgen ray fails to help us, notably those in which the tumor may be of such small size that it escapes observation in the picture or where it is obscured by other pathology, such as pulmonary suppuration in extensive form. I have in mind several cases in our own experience quite recently where that has happened. In one case there was extensive pulmonary suppuration in the right lung, upper and lower lobes. This was drained. At autopsy, some time subsequently, a sizeable carcinoma of the thymus gland was found, which did not appear in the roentgen study.

In another case, there had been extensive pulmonary suppuration with empyema and the individual at autopsy had a sizeable mediastinal sarcoma at the lower part of his chest, which had not appeared in any of the roentgenograms.

Then, again, as Dr. Evans has so well stated, the rôle of the roentgen ray is important as a therapeutic test. Unquestionably a certain number of tumors respond to roentgen irradiation and diminish in size, especially those that are of the sarcomatous and lymphosarcomatous types.

I feel, however, there may be some error in this procedure because of delay and false security that is set up if a change in the size of the tumor takes place, and this leads to the discarding or long postponement of operation. Unquestionably the keystone of success in treatment of these tumors is early diagnosis, in reaching a conclusion at a time before the tumor becomes inextricably blended in with the other thoracic structures so as to defy removal.

Is it not fair in this day of periodic health examination to urge periodic roentgen examination of the chest so that at some time a life may be saved or prolonged by the discovery in this fashion at an early stage of an intrathoracic growth?

Finally, is it not fair to explore the chest, to perform exploratory thoracotomy, when the cases are in doubt and diagnosis is not established? We feel that our technique surgically has progressed to that extent where perhaps with not the same degree of safety, but with a fair margin of safety, the thorax may be entered quite as well as the abdomen in a similar situation.

ROENTGEN DIAGNOSIS OF ANEURYSMS OF THE INNOMINATE ARTERY*

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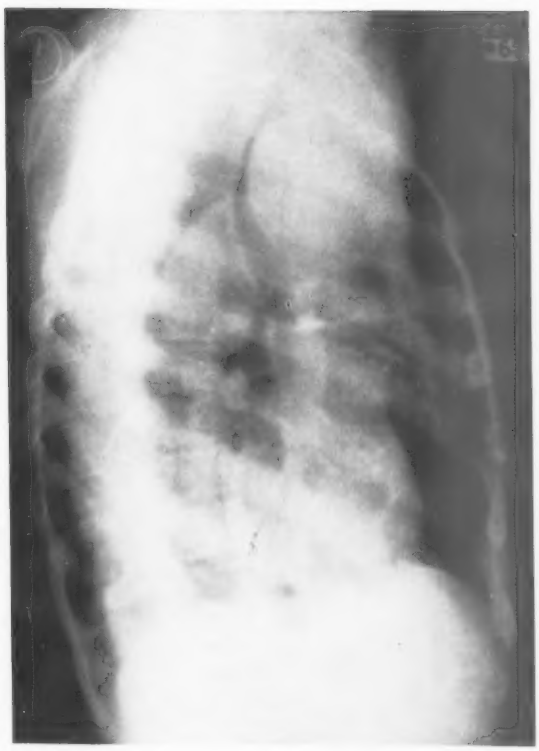
CHICAGO, ILLINOIS

DURING the last six years I have had occasion to examine and study 20 cases of aneurysm of the innominate artery; 12 cases, or 60 per cent, came to autopsy. Consequently, I feel sure we can correlate the findings.

I am chiefly interested in presenting the points of diagnosis as shown by the roentgenograms. However, I feel that, because of conflicting opinions, an analysis of the symptoms is in order. Williams[16] was probably the first roentgenologist to recognize an innominate aneurysm since he diagnosed one in 1897 by the roentgen ray, the case being reported by Dr. George W. Gay. Walsham,[14] in 1900, reported a case of aneurysm which, according to his description and illustration, may have been an aneurysm of the innominate artery. However, he made no mention of it. Kassabian,[9] in 1907, showed a lantern slide of one at the Philadelphia Medical Society. In 1901, Holzknecht[8] stated that the trachea and aorta were pushed to the left by aneurysms of the innominate artery. Groedel[5], in 1909, made a similar observation, but confined his remarks to the trachea. Hirschfelder,[7] in 1910, described the roentgen findings in the following words: "A ϕ-shaped shadow is seen on the left arm of the 'V' which the shadow of the innominate artery makes with that of the aorta on the left posterior to the right anterior illumination". Groedel[6] later stated that the aneurysm pulsated and projected upward and outward. He also stated that in some cases the normal innominate artery could be seen. He quotes Arnsperger as saying that in order to diagnose this aneurysm, there must be calcium in its walls. Vaquez and Bordet[13] state that the "radiological diagnosis of these sanguine tumors depends upon their topographic position; most often it will be easy enough to determine their exact position and from that their origin." Wessler and Jaches[15] state that these aneurysms are associated with disease of the aorta and that the shadow begins at the summit of the aortic arch and extends to the sternal end of the clavicle or a semicircular shadow situated above the inner end of the clavicle, just above the aorta. It is similar to a unilateral substernal thyroid but does not move with swallowing. The illustration in their book is very typical of this type of aneurysm. Assmann[1] states that the innominate artery is not normally seen but may be seen in cases of hypertension. He states that the denser shadows in this region are produced by aneurysms of the innominate and subclavian arteries. He gives an illustration in which is seen a shadow which runs obliquely upward from the aorta, fills the medial half of the upper right lung field and produces a characteristic angulation above the clavicle, pointing more medially where the angulation meets the carotid artery. He also demonstrates that the trachea is displaced to the left and the aortic knob depressed downward. Buchser[2] has called attention to the depression of the trachea on the right side with resulting angulation and destruction of the tracheal cartilage ring. Lupacciolu[11] reports 2 cases in which he shows the tumor to be in the upper third of the right mediastinum with or without pulsation. Köhler[10] states that if the aortic shadow projects far to the right and a second shadow runs upward and outward under the clavicle, we have probably to deal with an aneurysm of the innominate artery.

* Read at the Thirty-Fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

a



b

c

FIG. 1. L.W., aged thirty-seven, colored male. The semicircular shadow is seen in the right side of the superior mediastinum, arising at the level of the aorta. The oblique, *b*, and lateral, *c*, projections show compression of the trachea, dilatation of the aorta and the fusiform shadow in the superior mediastinum anterior.

ANATOMY

According to Gray[1] the innominate artery arises from the right ventral aorta between the truncus arteriosus and right fourth arch. It is the largest branch given off from the arch of the aorta, usually 4 to 5 centimeters in length. It arises on a level with the upper border of the second right costal cartilage from the commencement of the arch of the aorta in front of the left carotid and, ascending obliquely to the upper border of the right sternoclavicular articulation, divides into the right common carotid and right subclavian artery.

In front it is separated from the manubrium of the sternum by the sternohyoid and sternothyroid muscles, the remains of the thymus gland, the left innominate and right inferior thyroid vein which crosses its root, and sometimes the inferior cervical cardiac branch of the right vagus. Behind,

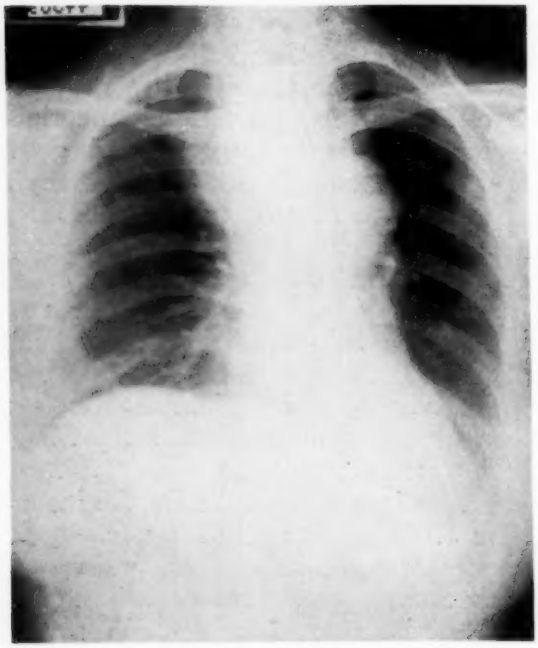


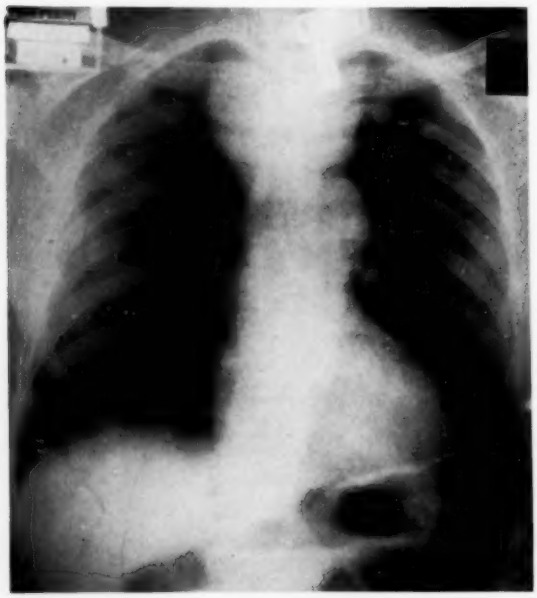
Fig. 2. C., aged forty-five, white female. Semicircular shadow in the superior mediastinum on the right side with aortitis.

it lies upon the trachea which it crosses obliquely. On the right side is the right innominate vein, right vagus nerve and the pleura; and on the left side the remains of thymus gland, the origin of the left carotid artery, the left inferior thyroid vein and the trachea.

It usually gives off no branches, but occasionally the small branch of the thyreoidea ima. The right recurrent laryngeal nerve arises from the vagus and passes in front of the right subclavian and then winds from before backward around that vessel and ascends obliquely to the side of the trachea behind the common carotid artery.

PATHOLOGY

The ascending and transverse portions of the aorta showed extensive wrinkling and puffing of the intima with numerous hyaline and fatty plaques. The circumference of the ascending portion of the aorta varied from 70 to 110 mm. Calcified plaques were found in several cases.



a *b*

Fig. 3, *a* and *b*. J. R., aged forty-three, colored male. Semicircular shadow in the superior mediastinum on the right side with compression of the trachea and aortitis. Marked dyspnea, death. Anatomical diagnosis: aortitis with saccular aneurysm of the innominate artery.

In each case, the innominate artery was transformed into a sac-like mass measuring from 45 to 70 mm. in the transverse diameter, 50 to 70 mm. in the vertical diameter, and 24 to 90 mm. in the anteroposterior diameter. This sac was filled with yellowish-gray to yellowish-brown blood clots. The intima was covered by a soft purplish-gray laminated membrane.

The right common carotid and right subclavian artery arose from the upper posterior portion of the sac and were not involved in the destructive process. Similarly, the left common carotid and left subclavian arteries were not involved. The opening of the innominate artery into the aorta was markedly dilated, distorted and involved in the destruction.

The sac compressed and bulged into the trachea and in all but two cases decubitus ulcers with softening of the cartilage rings were found about 4 cm. above the bifurcation. Only one case showed involvement of the right recurrent laryngeal nerve.

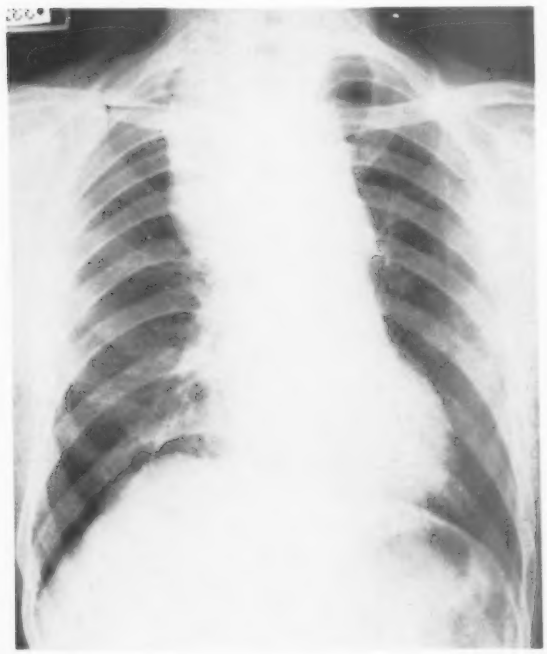


FIG. 4. E. D., aged fifty-five, colored male. Semicircular shadow in the superior mediastinum on the right side with compression of the trachea and aortitis. Marked dyspnea, death. Anatomical diagnosis: aortitis with saccular aneurysm of the innominate artery.

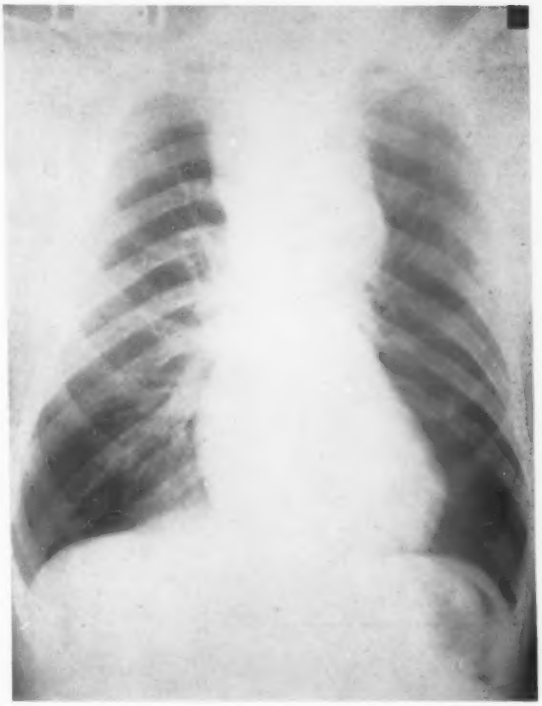


FIG. 5. J. S., aged forty-six, colored male. Anatomical diagnosis: saccular aneurysm of the innominate artery, with compression of the recurrent laryngeal nerve; syphilitic aortitis.

CLINICAL FINDINGS

Ferranti and Nizzi-Nuti[3] state that the symptomatology of their two cases was so characteristic and tallied so closely with the classical description of aneurysms of the innominate artery that a detailed discussion was unnecessary. Piersol[12] gives a list of the clinical findings which he explains on the basis of pressure on the neighboring blood vessels and nerves. He lists the following findings: (1) weakness of the radial pulse or right carotid pulse; (2) venous congestion of the face; (3) cough, hoarseness or aphonia, due to pressure on the right recurrent laryngeal nerve; (4) dilatation of the pupils, due to pressure on the sympathetic; (5) cough, due to pressure on the phrenic nerve; (6) pain in the arm, neck or head, due to pressure on the cervical or brachial plexus; (7) dyspnea

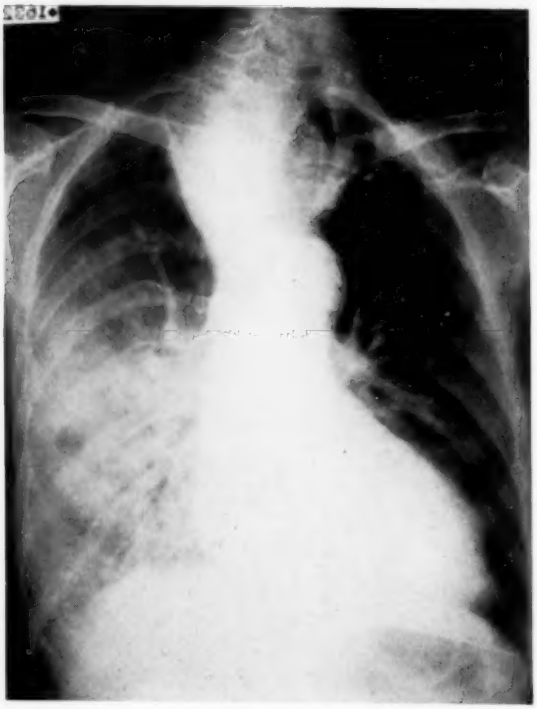
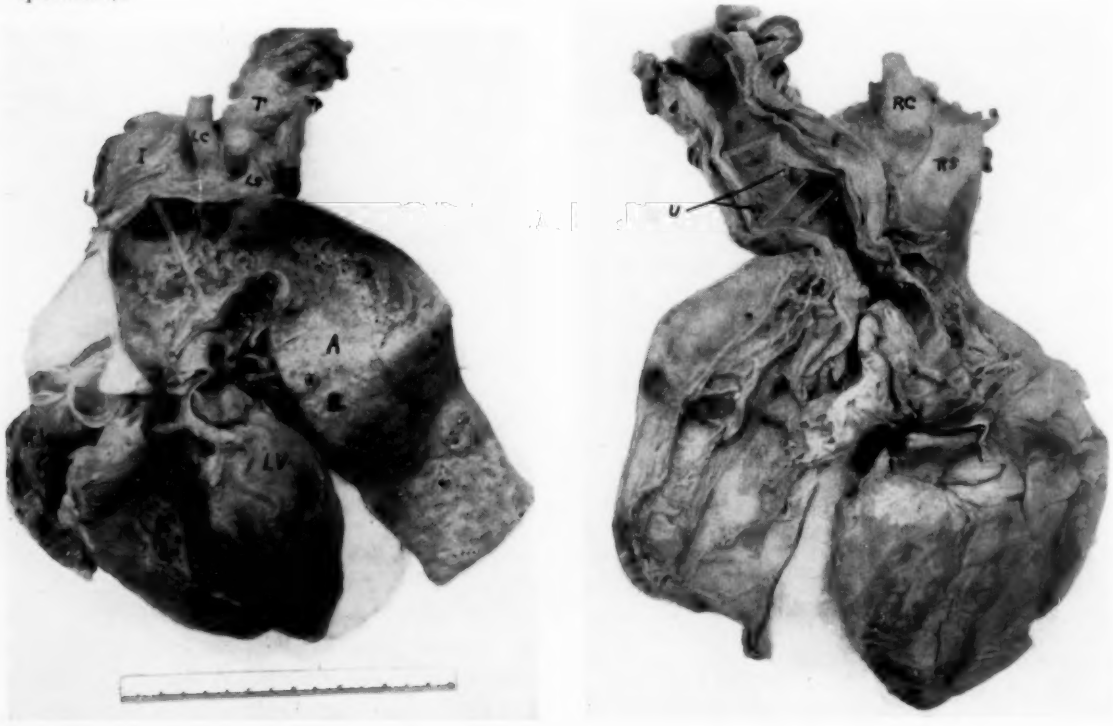


Fig. 6. W. Y., aged seventy-two, colored male. The tumor displaces the trachea to the left and occupies the typical location (see Fig. 7 for post-mortem specimen).

and dysphagia due to pressure on the trachea and esophagus, and (8) obliteration of the suprasternal depression with bulging at or above the right sternoclavicular articulation.

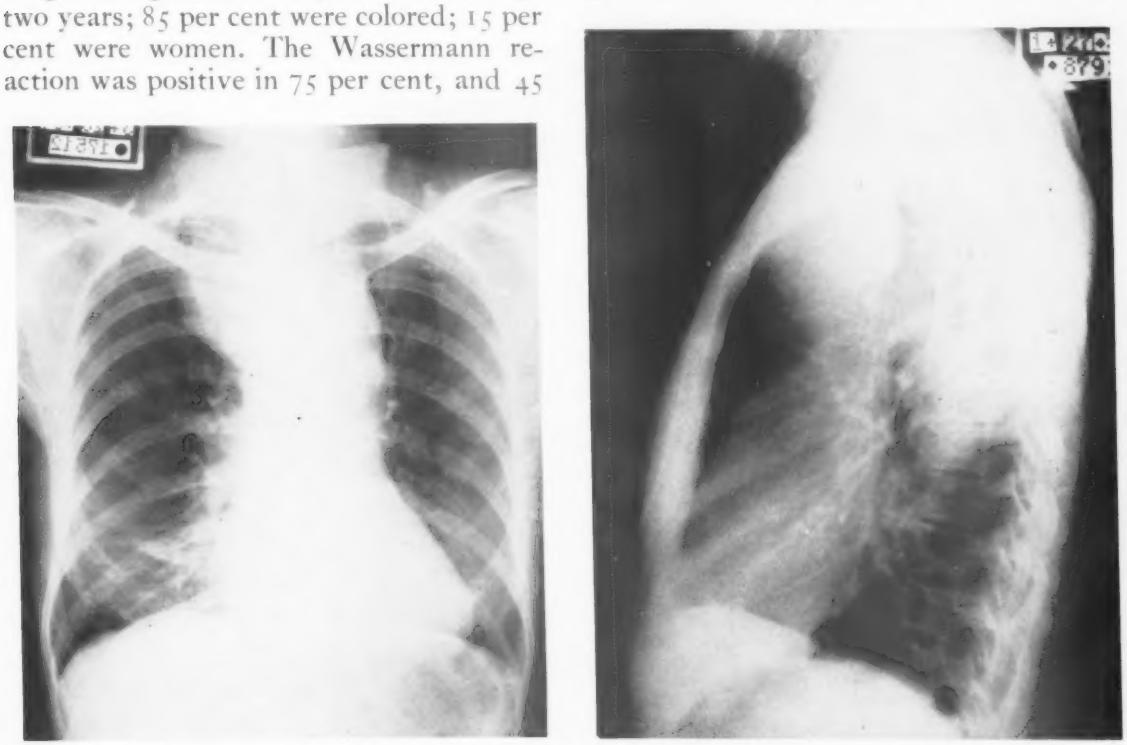
The clinical findings in our cases were not so definite and reliable as the above would lead one to believe. In fact, we feel that there are no classical symptoms pathognomonic of the condition. It does seem, however, that the clinical diagnosis of aortitis can be made in a fair number of cases. Of the 20 cases studied, 15, or 75 per cent, were diagnosed aortitis or aneurysm clinically. The difference in blood pressure in the two arms was of no significance since the readings in some cases were 10 to 15 points higher on the right, and in other cases on the left. In fact, one case had no demonstrable systolic pressure on the left side. We feel that a difference of 30 points between the two sides may be found in ordinary aneurysms of the arch of the aorta. Cough was present in 85 per cent of the cases, yet only 35 per cent had



a *b*

Fig. 7, *a* and *b*. W. Y. Post-mortem specimen of Figure 6. *A*, aorta; *E*, esophagus; *I*, innominate aneurysm; *L.C.*, left common carotid artery; *L.S.*, left subclavian artery; *L.V.*, left ventricle; *R.S*, right subclavian; *R.C.*, right common carotid artery; *R.V.*, right ventricle; *T*, trachea; *U*, ulcers of the tracheal mucosa. Note the wrinkling and puckering of the aorta and the large opening of the innominate artery.

a brassy cough, and the right recurrent laryngeal nerve was involved in only one of the autopsied cases. The cough was undoubtedly due to pressure on the trachea. Dyspnea was present in 85 per cent and pain or distress in 65 per cent. The patients ranged in age from thirty-five to seventy-two years; 85 per cent were colored; 15 per cent were women. The Wassermann reaction was positive in 75 per cent, and 45 per cent admitted chancres. In the larger aneurysms, we were able to palpate a tumor in the supraclavicular space, the tumor having a transmitted pulsation. Dizziness has been reported by Lupacciolu,[11] but only 2 of our cases complained of dizziness.



a *b*

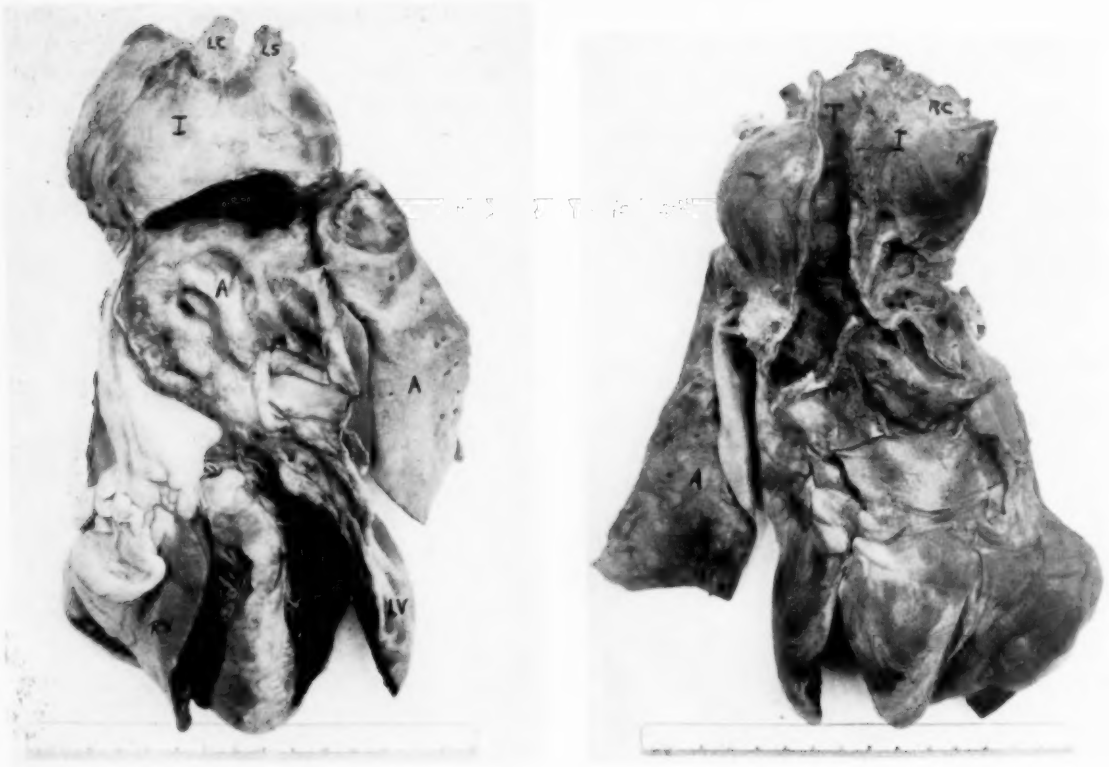
FIG. 8, *a* and *b*. H. McR., aged forty, colored female. Marked aortitis with dilatation of the aorta. The superior mediastinal tumor on the right side indicates involvement of the innominate artery (see Fig. 9 for post-mortem specimen).

ROENTGEN FINDINGS

In a study of these cases it was quite apparent that the diagnosis of aortitis must first be made before one can diagnose an aneurysm of the innominate artery. I do not wish to discuss the roentgen diagnosis of aortitis in this paper, since it has been dealt with by previous authors. Good posteroanterior, oblique and lateral films, together with roentgenoscopic examination, may be necessary to decide the earld or slight dilatations. In our cases we founy slight diffuse dilatations to marked saccular dilatations of the arch. It is our opinion that aneurysms of the innominate artery do not occur without involvement of the aorta.

The innominate aneurysm can be described as a superior mediastinal tumor arising on the right side at the upper level of the arch of the aorta and extending above the inner end of the clavicle. In extremely large aneurysms the shadow will also be on the left side. However, in this case the greatest enlargement is to the right.

Viewing the patient in the lateral and oblique positions we see a fusiform shadow originating at the arch of the aorta, bulging posteriorly so that compression of the trachea is a constant finding. Displacement



a *b*

Fig. 9, *a* and *b*, H. McR. Marked wrinkling and puckering of the aorta with dilatation and involvement of the innominate artery.

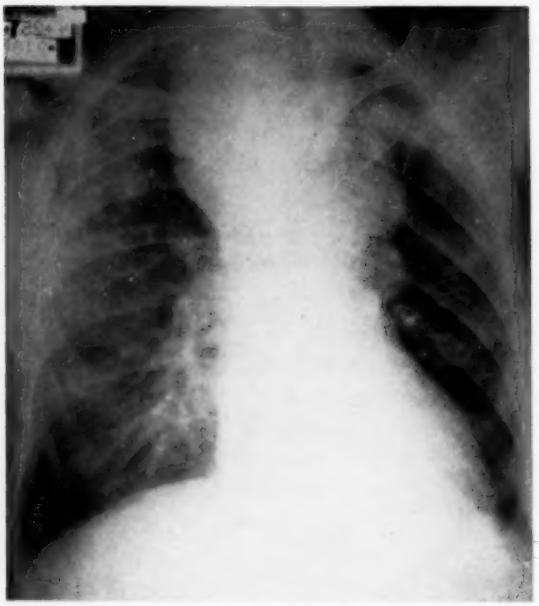


Fig. 10. E. S., aged fifty-two, colored male. Superior mediastinal tumor on the right side with aortitis (see Fig. 11 for post-mortem specimen).

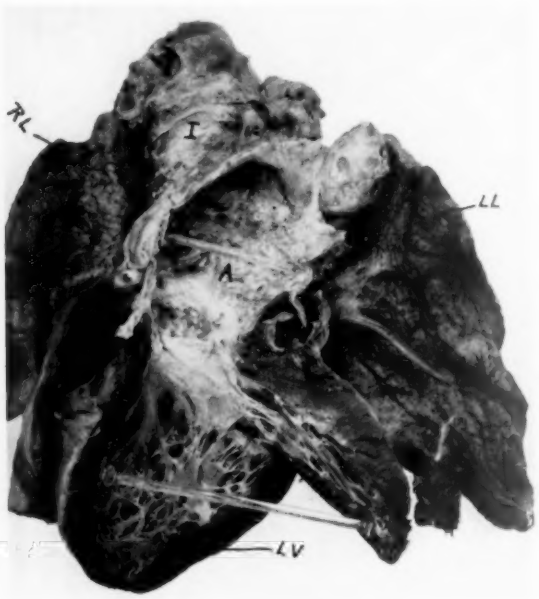


Fig. 11. E. S. Anatomical diagnosis: marked aortitis with dilatation and a saccular aneurysm of the innominate artery.

of the trachea to the left is not common, being present in only 15 per cent of the cases, due to the fact that the innominate artery lies more anterior to the trachea than to the right. This compression, together with constant beating against the trachea, frequently produces decubitus ulcers.

Expansile pulsations were seen in only 1 case; this is explained by the fact that in each of the 12 cases autopsied we found an organized thrombus in the aneurysmal sac. Transmitted pulsation was seen in nearly every case, but this is of no value, since it is also seen in mediastinal tumors.

DIFFERENTIAL DIAGNOSIS

A saccular aneurysm arising on the right upper portion of the arch of the aorta presents the greatest difficulties. I believe that it is not so common as the innominate aneurysm. The saccular aneurysm of this type does not produce compression of the trachea nor does it present a palpable transmitted pulsating mass in the supraclavicular space. It lacks the characteristic semicircular contour of an aneurysm of the innominate artery.

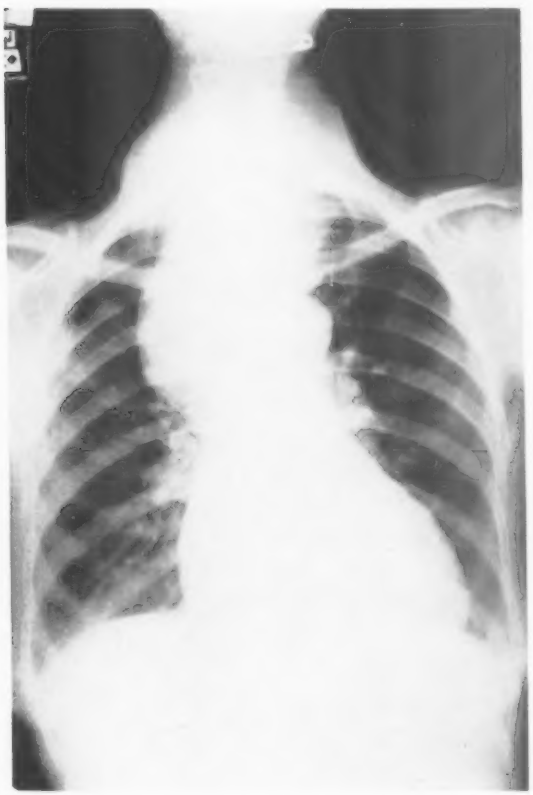


Fig. 12. Cystadenoma of the thyroid removed at operation.

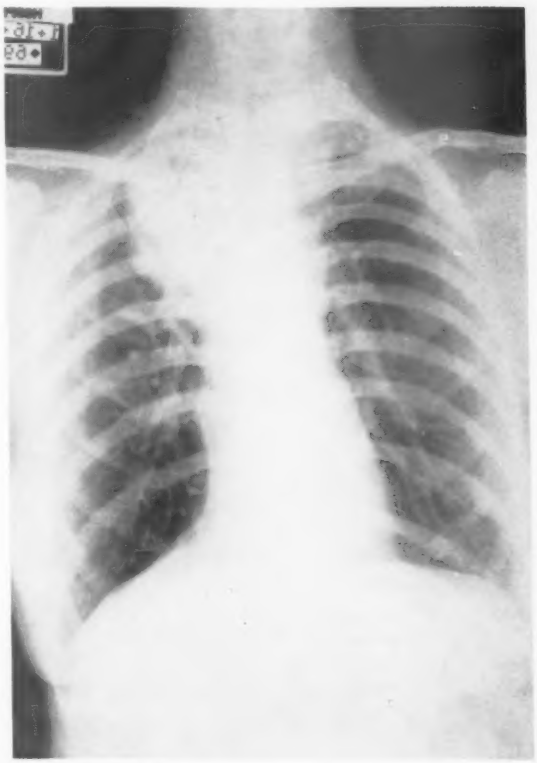


Fig. 13. Active tuberculosis with positive sputum.

A unilateral substernal thyroid on the right side depresses the arch of the aorta downward and displaces the trachea to the left. It widens from below upward, moves with the trachea and shows no transmitted pulsation.

A dermoid cyst in the right superior mediastinum is more anterior and sharply defined. Teeth or hair may be demonstrated in it.

Tuberculosis confining itself to the azygos lobe of the lung may add difficulty, but it is usually higher and its opacity is not uniform.

The superior vena cava may be prominent, yet this shadow is vertical and quite short and merges into the shadow of the right innominate vein.

A substernal abscess having origin in the pharynx gives a bilateral shadow with no transmitted pulsation.

Undifferentiated mediastinal tumors in this area may be confusing, yet in all tumors of this area I feel that a demonstration of aortitis must be made before one can diagnose aneurysm of the innominate artery.

CONCLUSION

The personal observation of 20 cases of aneurysm of the innominate artery makes me believe that it occurs more frequently in the larger clinics than is commonly thought and is overlooked because its characteristics have not been studied. A right-sided tumor in the superior mediastinum with associated aortitis should lead one to suspect this aneurysm.

I wish to thank Dr. Freedman of the Cleveland City Hospital for 3 of these cases.

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DISCUSSION

Dr. George W. Holmes, Boston. This presentation of Dr. Warfield's is complete and agrees entirely with my own observations. Therefore, there is nothing for me to do except to emphasize a point which he has brought out, namely, that this lesion invariably occurs as a complication of luetic aortitis. When an abnormal shadow is seen in the region of the innominate artery one should examine the aorta carefully; if evidence of aortitis is found aneurysm of the innominate is a probable diagnosis.

Vol. 33, No. 3

AN EVALUTION OF THE ROENTGEN FINDINGS IN GONORRHEAL ARTHRITIS*

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PROPOSITION: Are there any roentgen signs characteristic of gonorrheal arthritis? A few say yes; more say no; most are in doubt. The present study is an attempt to settle the issue.

ETIOLOGY

Gonococcal infection plays a prominent rôle in the etiology of the arthritides. Cooperman[7] remarks that more joints have been wrecked by gonorrhea than by all the other pyogenic infections combined. The incidence of joint involvement is variously estimated as 2 to 5 per cent[2,6] of all gonorrheal infections. While the urethra and cervix uteri are the common foci, cases of arthritis have been reported in new-born infants afflicted with gonorrheal ophthalmia,[32,33] and in children suffering with gonorrhea of the rectum.[6] The present series includes similarly an infant with vaginitis. In brief, it appears that any gonococcal focus may give rise to an arthritis.

CLINICAL FEATURES

Pepper[30] has presented us with a most comprehensive and modern review of the clinical diagnosis of gonococcal arthritis. Admitting the difficulties of such a diagnosis, he carefully evaluates every known aid under the headings: history, the character of the arthritis, other clinical features, the complement fixation test, roentgenology, joint puncture, the course of the disease, and the results of treatment. In the paragraphs immediately following are mentioned the salient clinical features elaborated by Pepper.

HISTORY

Significant historical data are clear stories of a previous gonorrhea, even though a subsequent arthritis may appear to be the result of an injury, for such injured joints frequently seem to become the seat of a gonococcal arthritis. It must be remembered that venereal disease is frequently denied or there may be a lack of awareness in the female. In the latter the presence of leucorrhea, pelvic inflammatory disease, or an arthritis developing after marriage or childbirth are significant. Pepper makes the interesting observation that patients having multiple attacks of gonorrhea followed by arthritis usually suffered joint complications after the first infection and then after each fresh one. Age is an important factor in ruling out rheumatic fever, primary attacks of which are not so common after the age of twenty.

CHARACTER OF THE ARTHRITIS

The character of gonococcal arthritis was first considered to be essentially monarthritic; later it was admitted to have a polyarthritic onset with ultimate localization in one large joint; and now it is alleged to be a frequent invader of the temporomandibular and sternoclavicular joints, which latter joints are probably never involved in rheumatic fever. Nevertheless Pepper states that "there is not enough difference in the onset, the order of involvement, the number of joints involved, those involved, the duration of individual joint involvement nor in the severity of the local symptoms to permit one to make a satisfactory differential diagnosis." There is current some belief that we are erroneously classifying as gonococcal two distinct forms of arthritis, the true type being more or less acute and often yielding the specific organism; the second variety being a chronic infectious process associated with

* Thesis submitted to the Faculty of Radiology of the Graduate School of Medicine of the University of Pennsylvania in partial fulfillment of the requirements for the degree of Master of Medical Science for graduate work in Radiology.

a gonococcal focus that has been secondarily invaded by other organisms. In this latter type the gonococcus would probably not be found in the affected joints and therefore would more properly be termed nonspecific. Forkner,[11] however, cultured gonococci from such a joint.

Nichols and Richardson,[25] after spending eight years in a clinical and pathologic study of 65 cases of arthritis deformans (chronic non-tuberculous arthritis), concluded that a wide range of articular disturbances may result from any one of a number of causes, and that any or all of these changes may result from any one cause. It is now generally admitted that any focus of infection, regardless of the agent, may through the processes of allergy[19] or the production of irritants[32] set up an arthritis. Zinsser[43] describes bacterial allergy as a condition in which the body is sensitized to a bacterial antigen, a state representing an increased capacity on the part of the tissue to react to this antigen which may either come to the body in the form of a new infection or through the lighting up of an old focus. Further, he adds: "This increased capacity to react may be injurious and result in pathological changes and disease."

OTHER CLINICAL FEATURES

Pepper failed to find any diagnostic significance in the type or duration of fever, the amount of sweating, the degree of leucocytosis, or the presence of anemia; all of which have been quoted variously by authorities as having specific clinical features.

COMPLEMENT FIXATION

A positive complement fixation test, secured prior to vaccine injection, is valuable as a confirmatory aid, but a negative reaction may be of no moment.

JOINT PUNCTURE

Joint puncture for aspiration in an acute affection will yield a cloudy fluid, which contains many neutrophils, and only occasionally are gonococci demonstrated. Biopsy of the synovial membrane is often necessary in order to discover the presence of the organism. Culture of neighboring lymph nodes for gonococci may sometimes obviate joint puncture.

COURSE OF DISEASE AND RESULTS OF TREATMENT

Salicylate relief is not sufficiently limited to rheumatic fever to rule out gonorrheal arthritis. The residual consequences of a gonococcal arthritis may be as mild as those of rheumatic fever but if the former runs an unduly long course in the large joints ankylosis frequently results. However, any acute infectious arthritis may produce an ankylosis.

Allison and Ghormley,[1] having made an exhaustive clinical and pathologic study of arthritis, state:

> In all forms of arthritis (with exception of the degenerative forms) the disease process primarily affects the 1. Synovial membrane which proliferates; 2. Marrow connective tissue which proliferates. The subsequent changes have a remarkable similarity no matter what the causative agent. And after once started the disease process may continue to operate even though the original cause has ceased to operate. Syphilis, tuberculosis, typhoid fever, gonorrhea and multiarticular progressive arthritis may each cause similar gross reactions in the tissues.

ROENTGENOLOGIC EVIDENCE

Without entering into details at this juncture, suffice it to say that Pepper and many other clinicians consider the roentgen ray a valuable adjunct in establishing the diagnosis of gonorrheal arthritis.

CLINICAL TYPES OF GONORRHEAL ARTHRITIS

Corbus,[8] writing in the *Medical Clinics of Chicago*, itemized Osler's classification of gonorrheal arthritis thus:

a. Arthralgic—manifested by wandering pains about the joints, without redness or swelling.

b. Polyarthritic—several swollen and tense joints with only slight fever.

c. Acute gonorrheal arthritis—a single joint,

usually the knee, is suddenly involved. Pain and swelling are marked due to periarticular edema. The exudate usually resolves.

d. Chronic hydrarthrosis—monoarticular, especially involving the knee. No pain, redness, nor swelling.

e. Septicemic—acute attack with blood invasion giving the picture of septico-pyemia, possibly with an associated endocarditis.

f. Bursal and synovial forms—localization in the tendons and their sheaths, in the bursae, and in the periosteum. The articulating surfaces may not be affected.

g. Painful heel—pododynia—due to local periosteal thickening and exostosis of the calcanei.

ACUTE PATHOLOGIC TYPE

Cooperman[7] considered the acute reactions as assuming one of three courses pathologically: (1) an exudative periarthritis; (2) an infectious synovitis; (3) a panarthritis. The first form, commonly noted in the smaller joints such as the wrist and ankle, is characterized by marked pain and periarticular swelling. The infectious synovitis type is more usually seen in the larger joints like the hip, knee and shoulder, where there occurs an intra-articular exudation that may be serous, serofibrinous, or purulent. The serous exudations are generally absorbed, leaving no residual damage. Intra-articular fibrosis forms as the aftermath of a serofibrinous exudate. The development of a panarthritis is usually due to a complicating pyogenic infection featured by osteo- and chondrolysis terminating in dislocations and ankyloses. "Gross inspection of these damaged joints variously reveals the presence of periarticular fibrosis, pannus formation, shredding and fibrillation of cartilage, and rarely a low grade periostitis and osteomyelitis."

PATHOLOGIC-PHYSIOLOGY

An explanation of the protean manifestations of gonorrheal arthritis rests on a hypothetical inquiry into the virulence of the attacking organisms, the resistance of the host, and the physiologic and histologic structure of the tissues involved. Pelouze[27] emphasizes the predilection of gonococci for columnar tissue epithelium such as is found in the male urethra. Luys, quoted by Ely,[10] alleges the outstanding focus from which the disease spreads to be in the seminal vesicles, where there is found a rich vascular stroma lined with columnar epithelium. The acute forms of gonorrheal arthritis are quite generally ascribed to the development of a bacteriemia, by invasion through the lymphatics or local blood vessels.[9,24,38] An explanation of the almost specific localization in the joints merits careful biochemical investigation, since synovial tissues lack the covering of columnar epithelium which Pelouze finds most favorable for gonococcal proliferation. The synovia are, however, composed of delicate connective tissue, lined with a thin flattened endothelium, through which tissue juices and joint contents are easily interchanged. Key[15] demonstrated the ready passage of carbon particles into the subsynovial tissues upon injecting the knee joint of rabbits with colloidal carbon. In another study, by means of the supravital method of staining, he showed that normal synovial fluid contrains from one to three hundred living cells per cubic millimeter constantly, together with a similar number of red blood cells, a small amount of fat, and tissue débris. In these reservoirs of nourishment the gonococcus no doubt finds an ideal culture medium.

In 1924 Phemister[31] cleverly demonstrated the dissolving action of pyogenic pus on cartilage as contrasted with tuberculous pus, which of itself produces little or no destruction of cartilage. He placed sections of articular cartilage in containers of pyogenic and tuberculous pus. Within a few hours there was marked destruction of the cartilage by the pyogenic pus, but in the container of tuberculous pus the sections showed no appreciable change even after several days. Phemister attributed this difference to the presence of polymorphonuclear cells in pyogenic exudate and the predominance of lymphocytes in tuberculous exudate. Proteolytic enzymes are released upon death of the former cells but

not of the latter. Gonococcal pus resembles the pyogenic in possessing a polynuclear predominance,[4] and would therefore tend to simulate the effects produced by pyogenic organisms. Nowhere in the literature have I found any suggestion that gonococci may have a direct specific action on bone or cartilage. Phemister[31] further says:

> In pyogenic arthritis the articular cartilage is broken down partly by the absorption of granulation tissue, partly by the erosive action of opposing articular surfaces upon each other and partly by the digestive action of proteolytic ferments, in the exudate of the joint, which are derived very largely from polynuclear cells and to a slight extent from broken down bacteria. Where the entire thickness of cartilage on both sides of the joint has been destroyed granulations grow out from the bone on both sides; fusion takes place; fibrocartilage forms along the line of junction, and ossification usually proceeds into the zone of fibrocartilage from both sides and eventually bony ankylosis results in most cases as described by Allison and Brooks.

ROENTGENOGRAPHIC CORRELATION

The diagnosis of gonorrheal arthritis on the roentgenogram, without the aid of clinical and pathologic data, is usually a difficult problem. Failure thus far to find specific microscopic changes[1,11,25] accounts in large measure for this apparent incompetence of the roentgenograms, for the roentgenologist's skill is limited to the interpretation of abnormal shadows cast by disease processes. However, most of the arthritic changes of gonococcal origin described by pathologists can usually be demonstrated on the roentgenogram. The variation in clinical behavior adds further to the complexities of making a diagnosis. In spite of its limitations, the roentgenogram, however, plays a most important rôle in confirming and establishing the extent of joint involvement, as well as revealing the progress of destruction or repair.[4]

Wehrbein,[42] after having studied 610 cases of gonorrheal arthritis, could not discover any definite characteristic features; Cooperman[7] found nothing distinctive in a review of 44 cases occurring in infants and of 70 cases in adults.

Köhler[20] says:

> If the spongy tissue of the bone shows an irregular, mottled appearance while the cortex is as thin as a pencil line, that is the highest degree of acute atrophy of the bone; if there be no fracture or severe injury, this atrophy is a sign of commencing tuberculous arthritis, osteomyelitis, or gonorrheal arthritis; it is never met with in syphilitic cases nor in arthritis deformans. Senile atrophy of bone in comparison with this acute atrophy is relatively rare and is usually homogeneous, that is without mottling or marbling.

Haenisch and Holthusen[13] say that while the clinical characteristics of mon-articular involvement are extreme pain and especially a high grade spotty bone atrophy with rapid progressive destruction, these characteristics are not specific.

Spotty ground glass atrophy of the bones neighboring an arthritis has been considered suggestive of a gonococcal etiology by Pancoast[26] and Pendergrass.[29] And if there is no evidence of a serious streptococcic or pneumococcic infection a gonococcic etiology is more strongly suspected.[30] Key[18] similarly considers early, acute, localized atrophy significant but not specific.

A narrow zone of rarefaction was noted about one millimeter beneath the articular cortex in a few cases of the present series, but this same appearance was found in some cases of non-gonorrheal infectious arthritis. Therefore no special importance was attached to this observation.

Cattaneo[4] in an analysis of 100 cases, emphasizes the not infrequent occurrence of osteoporosis, portrayed as moth-eaten vacuolated areas which may be several millimeters in diameter and extend the width of the joint. He quotes Delorme as the originator of the idea that these moth-eaten areas are characteristic of gonorrheal arthritis, but also states that others deny this. Wehrbein[42] found these small areas of decalcification to be common, but due to lack of comparative material, declared

it impossible to say they were pathognomonic. Allison and Ghormley[1] attach no specific significance to osteoporosis.

Bone erosions are frequently found in acute gonorrheal arthritis according to others[1,23,24] and this series. Sometimes a punched out appearance may be simulated or the cartilage alone may be affected. Osteolysis and chondrolysis are typical expressions of the pathologic changes found in an acute infectious arthritis[25] whether of pyogenic or gonococcal origin. The apparent overgrowth of bone at the edges of such joints may simply be a flaring effect due to pressure of the softened osseous structure.

Ankylosis may be expected whenever there has been an extensive destruction of the articular cartilage. This may be bony or fibrous in type, depending on the processes described so well by Allison and Brooks in Phemister's quotation above. Cattaneo[4] considers the degree of ankylosis predictable from the roentgenographic evidence of cartilage destruction. Ankylosis between the patella and femur has been suggested as a fairly definite characteristic of gonorrheal arthritis,[39] but this has not been confirmed in my studies. Ankyloses were observed in various joints of the cases studied in the present series, but in none was the patella so involved.

Widening of the joint spaces may be found in an early intra-articular gonorrheal effusion, and is best seen beneath the patella and in the small joints. Loewenstein[23] alleges that a prolonged large effusion may mechanically stretch the capsular ligaments and subsequently lead to subluxation. A type of deforming arthritis may be thus explained. Periarticular swelling in the neighborhood of small bones, such as those of the carpus and tarsus, may conversely be expected to produce narrowing of the joint spaces.

Proliferative changes are common in so-called chronic gonococcal arthritis. Osteophytes or exostoses may be found in any of various bones. For a long time calcaneal spurs have been considered characteristic of gonorrhea. Baetjer and Waters[3] differentiated two types of such exostoses. The first type was recognized as a true exostosis of non-gonorrheal origin, growing out from the posterior-inferior tubercles of the os calcis and possessing normal bone structure. The second type, considered as gonorrheal in origin, characteristically arose outside of the bone, was laid down in layers, did not have normal bone structure, and usually became attached in the neighborhood of the posterior tubercles. Such specific differentiation is no longer recognized. Geschickter and Copeland[12] found these infectious osteophytes, including those of gonorrhea, to be microscopically similar to neoplastic osteochondromata in both structure and histogenesis. In the neighborhood of joints all the surrounding tissues (capsule, ligaments, synovia, tendon) may produce bone.[14]

Marginal exostoses, according to Lang,[21] arise as the result of vascularization and ossification originating in the subchondral marrow spaces. Damage to articular cartilage by functional traumata removes the protection ordinarily given to the subchondral bone. Thus are derived, says Lang, the characteristic appearances of proliferative arthritis.

CLINICAL DIFFERENTIAL DIAGNOSIS

The protean manifestations of gonococcal arthritis necessarily simulate a wide variety of joint affections. Rheumatic fever is generally more amenable to salicylate therapy, occurs earlier in life, and leaves no residual joint damage. Tuberculosis has a more insidious onset, does not flit from joint to joint and usually produces decalcification without distortion of the bone structure. However, there has come to my attention a case of clinical tuberculosis of the elbow in which there is extensive destruction associated with ground glass atrophy, simulating an acute suppurative arthritis. The punched out appearance of syphilis must be confirmed by the appropriate blood tests in the presence of a gonorrheal history. In arthritis deformans

a history indicating a gonococcal etiology may occasionally be elicited. Calcaneal spurs have a varied etiology among which arteriosclerosis, chronic infection, gonorrhea and metabolic dysfunction have been prominently mentioned[12,14]

PRESUMPTIVE SERIES OF GONORRHEAL ARTHRITIS*

Case 1. This patient was a white, single, female, aged nineteen. She was admitted to the University Hospital November 9, 1931, complaining of pain in the left thigh, radiating to the foot. Shortly after attending a dance in August she developed a leucorrheal discharge. Pain in the left hip began October 25, 1931. On admission it was practically impossible to examine the left leg because of excruciating

Fig. 1. Case 1.

pain on the slightest movement. Foul leucorrhea was present. The white blood cell count was 11,500 with 70 per cent hemoglobin and a moderate anemia. The blood Wassermann was negative. Repeated vaginal smears were negative for gonococci. The gonococcal complement fixation test was strongly positive.

Roentgenographic examination of the left hip on November 11, 1931, showed an extensive swelling of the periarticular soft tissues, haziness of the hip joint, an irregular destruction of the acetabular rim and beginning ground glass atrophy of the femoral head (Fig. 1).

Re-examination on December 1, 1931, showed considerable reduction in the periarticular swelling, a progression of the articular process with a reactive osteitis of the acetabular rim and a beginning spotty destruction of the femoral head. At the time of discharge on December 1, 1931, the coxitis was practically quiescent.

Fig. 2. Case 1.

The third examination on December 21, 1931, showed an apparent upward shift of the left hip, a considerable reduction in the periarticular swelling, a narrowing of the joint space, and an increased atrophy of the femoral head (Fig. 2).

A fourth examination on January 9, 1932, showed an apparent shift of the acetabulum upward about 1 inch, almost complete obliteration of the joint space, mottling of the femoral head, and an irregular erosion 1×1.5 cm., located at the middle of the superior margin of the femur (Fig. 3).

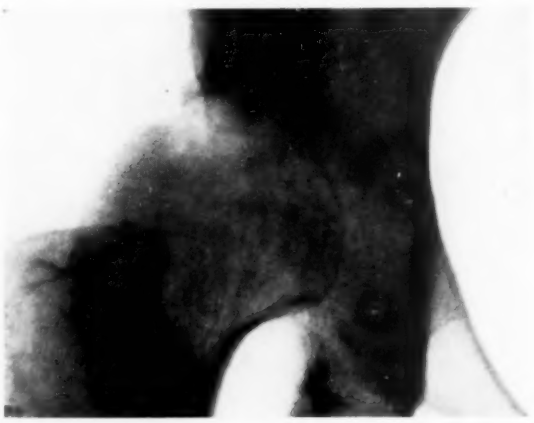

Fig. 3. Case 1.

The history of a leucorrheal discharge with a strongly positive gonococcal complement fixation test favored the diagnosis of gonorrheal arthritis.

* For the privilege of making the following case reports, I feel deeply indebted to the staffs of both the University and the Graduate Hospitals.

Case II. This patient was a widower, white, aged forty-six, admitted to the University Hospital on January 25, 1931. His chief complaint was stiffness of the right hip, both elbows, and the second joint of the ring finger of the right hand. In October, 1929, he suffered a sudden onset of severe pain in the right hip. Shortly both elbows and the right ring finger were similarly affected. The arthritic symptoms became quiescent in March, 1930, but the joints were stiff. In December, 1930, the joint pains recurred. Examination of a smear taken from the urethra on admission revealed the presence of gonococci. The blood Wassermann was negative. There was evidence of dental and tonsillar infections. Movement in the above joints was limited.

Roentgenograms made on January 30, 1931, demonstrated bony union of the right elbow joint with flaring of the anterior lip of the radius and an associated erosion of the capitellum. The left elbow was partially ankylosed. The right hip showed an irregular narrowing of the joint space, due to destruction of the articular cartilage. There was a complementary crenation of the acetabulum and the femoral head, resulting in a coglike joint and producing ankylosis by deformity. There was an hypertrophic flaring of the lateral rim of the acetabulum. The appearances of the hip were probably due to an early acute destruction of the articular cartilage, with subsequent degenerative changes (Fig. 4).

The presence of gonococci in the urethral smears offered an important clue in making a diagnosis of specific arthritis.

Case III. A white male, aged twenty-six, was admitted to the University Hospital on October 24, 1928, complaining of pains in the knee, ankle, hand, toes, and wrist on the right side. He was in good health until October 10, 1928, when there was a sudden onset of pain that involved the right foot; then the right ankle, toes, and knee. Motion aggravated the pain. He had profuse sweats and was feverish. Occasional frontal headaches and sore throat were disclosed in his past history. There were no previous rheumatic attacks. The tonsils were large and infected. The blood Wassermann was negative. Prostatic smears were negative for gonococci. The gonococcal complement fixation test was doubtful at first, then positive. There was a persistence of pain despite continued salicylate therapy. The patient denied ever having had gonorrhea. There were football accidents to the right ankle in 1921, 1922, and 1925.

Roentgenographic examination of the right ankle on November 15, 1928, demonstrated no evidence of bone or joint changes. A re-examination on December 6, 1928 showed a spotty ground glass atrophy of practically all the tarsal bones and the adjoining bases of the metatarsals. In the anterior articulating portion of the internal cuneiform there was noted a narrow zone of rarefaction 1 mm. back of the articular cortex. The joint spaces were generally

Fig. 4. Case II.

indistinct due to narrowing, haziness, and bands of fibro-osseous ankylosis (Fig. 5). No other roentgenograms were made.

A diagnosis of specific arthritis was based largely on the positive gonococcal complement fixation test and ground glass atrophy of the bones.

Case IV. A white female, aged twenty, was admitted to the University Hospital on November 25, 1929, complaining of lower abdominal pain and swelling of the left ankle and right index finger. Following coitus in October, 1927, a yellow, purulent, intermenstrual discharge developed followed by burning, frequency, and urgency of urination. About April 7, 1928, she suddenly developed pain in the right index finger and left ankle with subsequent swelling. There was a severe constitutional reaction. Later the right shoulder and jaw became affected. The pain eventually localized in the left ankle. The blood Wassermann was negative. The gonoccocal complement fixation test was strongly positive.

Fig. 5. Case III.

Roentgenographic examination of the right index finger revealed the presence of ankylosis with deformity at the middle phalangeal joint. All the bones of the left foot and ankle showed a generalized atrophy with localized ground glass appearances in some of the tarsal bones.

A diagnosis of gonorrheal arthritis was favored by the history and clinical findings of a vaginal discharge, positive complement fixation test, urethritis, and involvement of the temporomandibular joint.

Case V. A white male patient, aged thirty, was admitted to the University Hospital on July 20, 1928, complaining of stiffness and pain in the joints, which first began in 1922, one week after an anterior urethritis. First a mandibular joint was affected and then the knees, ankles, and feet. Ten months later the patient had a recurrence of both an urethritis and an arthritis. On this occasion the shoulder joints and chest were additionally involved. In 1927 there was another recurrence. Prostatic smears at the time of admission revealed a moderate amount of pus. There was evidence of disease in the tonsils. The blood Wassermann was negative.

Roentgenographic examination revealed generalized atrophy of the right carpal bones and all the bones of the left foot. In some of the joints of the foot the articular cartilage had been destroyed, especially that of the metatarso-phalangeal joints, resulting in subluxations. There was a localized area of ground glass atrophy involving the anterior half of the astragalus. A broad-based horizontal exostosis arose from the posterior, inferior tubercles of the os calcis. At the insertion of the tendo Achillis there was noted a flattened, irregular exostosis. This case of chronic deforming arthritis was apparently caused by repeated gonorrheal infections (Figs. 6 and 7).

Case VI. A white male, aged fifteen, was admitted to the Graduate Hospital on June 27, 1927, complaining of pain in the right foot. One year previously he suffered a contusion of the same foot. On June 11, 1927, he had an attack of urethritis five days after exposure. On June 15, four days later, there was an onset of polyarthritis involving the shoulders, knees, cervical spine, fingers of the right hand, and toes of the right foot. The process finally localized in the foot with swelling and pain as symptoms. There was no limitation of motion. The urethral

Fig. 6. Case V.

smears were negative for gonococci. The blood Wassermann was negative. The urine was cloudy.

Roentgenographic examination on July 1, showed an irregular erosion at the proximal end of the right middle toe. The articular margin of the adjoining metatarsal was indistinct and there was an apparent widening of the joint space (Fig. 8).

A preceding urethritis favored a gonococcal etiology for the subsequent arthritis.

Case vii. This patient, a white male, aged twenty-three, was admitted to the Graduate Hospital on January 16, 1929, complaining of pain in both heels and in the spine. In 1922 he contracted gonorrhea which he treated himself. In 1923 he suffered with "rheumatism" of the right foot which persisted for one year. On December 1, 1928, he noticed an urethral discharge which cleared up under a physician's care. Joint pains were intermittent over a long period of time, but were not severe until August 28, 1928, when he was forced to give up his work.

Roentgenograms of both feet demonstrated bilateral, horizontal, calcaneal spurs, the one on the right being much larger than the one on the left. There was a small osteophyte of the right transverse process of the seventh dorsal vertebra (Fig. 9).

Fig. 7. Case v.

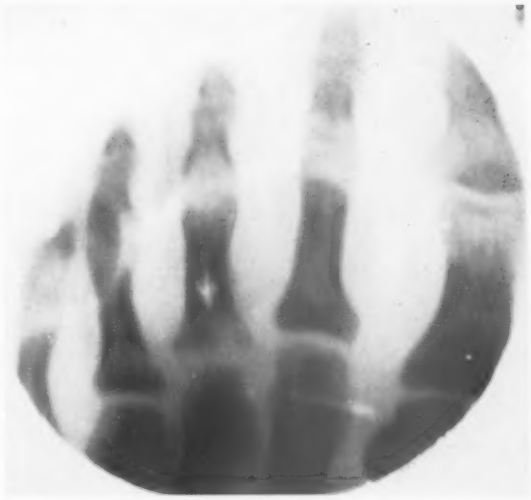

Fig. 8. Case vi.

Case viii. A white female, aged twenty-one, was admitted to the Graduate Hospital on September 27, 1929, complaining of pain in the left foot. Four weeks previously she took a bath during her menstrual period and developed a cold. Four days later she developed an acute pain in the left ankle which did not swell until later. The gonococcal complement fixation test was negative. A profuse mucopurulent leucorrhea was found, but there was no sign of external infection. Smears taken from the

Fig. 9. Case vii.

urethra and cervix were negative for gonococci. The blood culture was negative.

A roentgenogram of the left foot showed clouding and widening of the second tarso-metatarsal joint. The cortex of the adjoining metatarsals was indistinct and there was a triangular erosion of the internal cuneiform (Fig. 10). The developments in this case suggested the presence of an acute gonorrheal arthritis although the only clinical evidence was a mucopurulent vaginal discharge.

Fig. 10. Case viii.

Case ix. A white female, aged twenty-seven, was admitted to the Graduate Hospital on August 5, 1931, complaining of pain and stiffness in the left ankle. In September, 1929, she first noticed stiffness in her hands and later, swelling. Subsequently the shoulders and the back became involved and in October, 1929, the left ankle was affected. Symptoms in the left ankle persisted more or less continuously. At the time of admission a yellow, foul, vaginal discharge was found. A diagnosis of endocervicitis was made.

Roentgenograms made of the left ankle and foot showed a spotty atrophy of practically all of the bones. A vaginal discharge was the only clinical evidence favoring a diagnosis of gonorrheal arthritis.

Case x. A white male, aged twenty-four, came to the Orthopedic Dispensary of the University Hospital on April 26, 1932, complaining of pains in both feet including the heels. He admitted having had gonorrhea four years previously, lasting four months. Foot pains began shortly after contracting gonorrhea and continued intermittently.

Roentgenograms of both feet showed the presence of a generalized atrophy of practically all of the bones, ankylosis of several metatarsophalangeal joints in both feet and bilateral, horizontal calcaneal spurs. The chronological relation of the arthritis to the gonorrhea favored the diagnosis of a gonococcal etiology.

Case xi. A white male patient, aged twenty-two, was admitted to the University Hospital on June 9, 1931, complaining of painful swelling in the joints. He enjoyed good health until March 16, 1931, when he bruised his left foot on a steel girder. Pain and swelling followed. A roentgenogram at that time revealed no evidence of fracture or dislocation. On March 30, 1931, the right ankle became swollen and tender, and ten days later the left knee became involved. On May 19, 1931, there was an onset of pain in both wrists and the right shoulder. There was a persistent swelling of the left knee and ankle. In 1924 he had a Neisserian urethritis which cleared up after nine months of treatment. There had been no discharge since that time. Patient gave no history of rheumatic attacks. The prostate was moderately enlarged. The tonsils were diseased. A gonococcal complement fixation test was medium positive.

Roentgenographic examinations: Both knees and the right ankle were negative. The left ankle showed spotty ground glass atrophy of some of the tarsal bones. A diagnosis of gonorrheal arthritis was clinically corroborated by the history of a past specific urethritis and a positive gonococcal complement fixation test.

Case xii. A white female, aged twenty-one, came to the Surgical Dispensary of the University Hospital on October 29, 1929, with pain and swelling of the left elbow. The duration of the arthritis was two weeks. The patient had a suggestive endocervicitis, but the smears were negative. The gonococcal complement fixation test was negative.

Roentgenograms of the left elbow on October 29, revealed moderate periarticular swelling, but there were no changes in the bones of the joint. Seven weeks later the periarticular swell-

ing had disappeared, but there was almost complete loss of the humero-ulnar joint space. There was evidence of a reactive osteitis in both bones, simulating an attempt at ankylosis. The appearances were suggestive of an acute infectious osteoarthritis, possibly of gonococcal etiology.

Case xiii. A colored male, aged twenty-eight, was admitted to the Graduate Hospital on February 22, 1928, with pain in the rectum and a urethral discharge. In 1921 he first contracted gonorrhea and had an associated involvement of the prostate. A second attack occurred five days before admission, again associated with prostatic extension. On April 26, 1928, a small fluctuating mass was palpated in the region of the right elbow. Pain and swelling soon followed and brought on limited motion.

Roentgenograms made on May 29, 1928, showed haziness and narrowing of the elbow joint associated with periarticular swelling of the soft tissues. There was also noted a beginning osteoporosis of the humeral condyles and a reactive osteitis in the articulating portion of the ulna. A culture of an aspiration taken from the elbow joint proved to be sterile. A blood culture was sterile. Prostatic smears were negative. Apical infections were disclosed around the roots of at least four teeth.

Re-examination of the right elbow on July 7, 1928, showed progression of the destructive processes with an apparent ankylosis of the ulna and humerus (Fig. 11). In view of a preceding specific urethritis a diagnosis of gonorrheal arthritis seemed most plausible.

Case xiv. A colored female, aged seventeen, was admitted to the University Hospital on December 12, 1931, complaining of pain and swelling in the right knee. The date of her last intercourse was October, 1931; two weeks later she noticed a vaginal discharge which lasted three weeks. On December 1, 1931, there was a gradual onset of pain and swelling in the right knee. The gonococcal complement fixation test was negative. The blood Wassermann was positive.

On examination the patient was found to have a vaginitis and an arthritis with effusion of the right knee. Smears made from joint aspiration were negative for gonococci but showed many polymorphonuclears and a few lymphocytes.

Roentgenograms of the knee on July 6, 1932, showed the presence of two small erosions opposing each other on the articular surfaces of the femur and tibia. There was also noted a moderate periarticular swelling of the soft tissues. The history and clinical findings presented undoubted evidence of a gonorrheal arthritis.

Case xv. A white female, aged thirty-three, was admitted to the University Hospital on December 8, 1927, with pain and swelling of the right knee. In 1923 the patient had a vaginal catarrh, and in 1924 a miscarriage. On November 16, 1927, a sharp pain developed in the right knee, calf, and foot. The knee was swollen, red, and hot. The following day the symptoms were localized to the knee. Smears

Fig. 11. Case xiii.

taken from the urethra and vagina were positive for gonococci. The tonsils appeared to harbor infection. The gonococcal complement fixation test was negative. Roentgenograms of the teeth were negative.

Roentgenograms of the right knee revealed the presence of an intra- and periarticular effusion with apparent widening of the joint space. There was a circular area of rarefaction about 0.5 cm. in diameter beneath the external spine of the tibia. The history and laboratory evidence favored the diagnosis of gonorrheal arthritis.

Case xvi. A white female, aged eighteen, was admitted to the Graduate Hospital on July 9, 1929, with a swollen, painful, left knee.

Fig. 12. Case xvii.

On June 16, 1929, the patient noticed burning on urination and pain about the urethra. A few days later she had severe pain in her right wrist and left shoulder. On June 30, 1929, her left knee became involved and gradually swelled and became hot. On vaginal examination a purulent discharge was found. Bimanual palpation elicited tenderness over both adnexal regions. Urethra was inflamed. Cervical smears were positive for gonococci. Gram negative intracellular diplococci were found in a smear made from an aspiration of the joint. Both tonsils were diseased.

Roentgenograms revealed a massive periarticular swelling of the soft tissues and blurring of the articular margins of all of the bones, including the patella. There was noted a narrow zone of rarefaction, 1 mm. beneath the articular cortex. The clinical history and positive smears confirmed the diagnosis of gonorrheal arthritis.

Case xvii. A colored male, aged forty-six, was admitted to the Graduate Hospital on November 23, 1928, with pain in the knees and ankles. At the age of eighteen he admitted having had gonorrhea and syphilis. On September 1, 1928, the left knee began to ache and swell. A week later the left hip and both shoulders began to ache. On admission tenderness was elicited on motion of the right mandibular joint. Both ankles were swollen and painful. The blood Wassermann reading was four plus. The gonococcal complement fixation test was positive.

Roentgenograms made on November 24, 1928, showed a spotty, honey-combed, osteoporosis of the left patella and femoral condyles (Fig. 12). The right knee, both shoulder joints, and both feet were negative. An arthritis of gonococcal etiology seemed most obvious from the clinical findings.

Case xviii. A white female, aged twenty-seven, was admitted to the Graduate Hospital on July 24, 1931, complaining of lower abdominal pain. Pelvic examination disclosed the presence of a palpable mass with extreme tenderness in the left adnexal region. Gonococcal complement fixation test was negative. On August 8, 1931, there was an onset of pain and swelling of the right knee. Cultures made of the joint fluid gave no growth.

Roentgenographic examination of the right knee on September 8, 1931, showed a moderate indurative swelling of the soft tissues about the joint. There were small semilunar erosions at the inner and outer edges of the femoral condyles and a less regular erosion of the internal facet of the tibia (Fig. 13). A diagnosis of gonorrheal arthritis was clinically supported by a history of painful micturition and pelvic inflammatory disease.

Case xix. A white female, aged twenty-eight, was admitted to the Graduate Hospital on March 23, 1925, with a complaint of left knee deformity. The patient stated that eighteen months previously, while sitting in a theatre, her knee became extremely painful. Subsequently her knee became flexed and extension

Fig. 13. Case xviii.

was impossible. The whole leg from above the knee downward, became sore and swollen. The patient admitted having had a mucopurulent discharge from the vagina preceding the arthritic onset. The blood Wassermann was negative and the gonococcal complement fixation test was positive.

Roentgenograms of the left knee showed flexion deformity of about 30°. The normal trabecular structure of the bones had been replaced by uniform, ground glass structure. The articular cartilage had been thinned and the articular cortex of the femoral condyles was dense and irregular. There was a triangular island of bone in the external synovial structures. A diagnosis of gonorrheal arthritis received ready support in the history and positive fixation test.

Case xx. A colored female, aged forty-seven, was admitted to the Graduate Hospital on July 31, 1931, with pain and stiffness in both knees. She admitted having had several miscarriages at three to five months of pregnancy. About fifteen years ago her knees first began trouble her. The onset was gradual and the course intermittent. The blood Wassermann and gonococcal fixation test were negative. Tonsils were diseased.

Roentgenograms revealed the presence of a bilateral atrophic osteoarthritis of the knees. The external condyles of both femurs had an exostosis (Figs. 14 and 15). The history of several miscarriages was the only clinical evidence in favor of this being a gonorrheal arthritis.

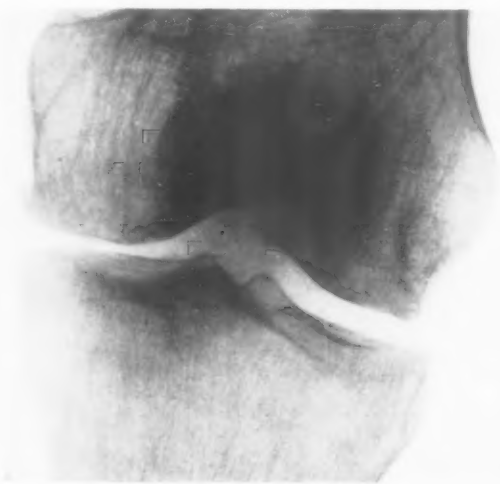

Fig. 14. Case xx.

Fig. 15. Case xx.

Case xxi. A white male, aged twenty-three, was admitted to the Skin Dispensary of the University Hospital on May 2, 1927. Clinically, he had both gonorrhea and syphilis. Further details were not obtained because the patient's chart could not be located. There was a polyarticular arthritis involving both wrists, elbows, and the right knee.

Roentgenograms made on May 3, 1927, showed a generalized atrophy of the left wrist with preservation of the joint spaces. Re-examination six months later showed a fusion of all the carpal bones into practically one mass. The proximal and distal carpal joint spaces were considerably narrowed and there was an ankylosis of the second metacarpal to the carpal mass. The arthritis was admittedly gonorrheal in origin.

Case xxii. A white female, aged nineteen, was admitted to the University Hospital on April 11, 1924, with pain and swelling of the left hand. There was a polyarthritic onset on April 5, 1924, with localization in the left hand. All smears were positive for gonococci. The gonococcal complement fixation test was negative.

The roentgenogram made on April 16, 1924, showed moderate swelling of the periarticular structure but no bone changes.

Re-examination on May 1, 1924, showed reduction in the periarticular swelling, haziness of the carpal joints, and ground glass atrophy of the carpal bones. Positive smear examinations helped confirm the diagnosis of gonorrheal arthritis.

Case xxiii. A white female, aged twenty-one, was admitted to the Orthopedic Dispensary of the Graduate Hospital on June 30, 1930, complaining of pain in the left wrist. The patient admitted having a vaginal discharge. Vaginal smears were negative. There was evidence of dental infection.

The roentgenogram made on May 17, 1932, showed a moderate decalcification of the left wrist. On June 30, 1932, there was noted a spotty decalcification of the wrist bones. On

Fig. 16. Case xxiv.

July 8, 1932, re-examination revealed an improvement approximating the normal in appearance. This interesting case of an apparent recovery in the arthritic processes was clinically confirmed as gonorrheal only by the presence of a vaginal discharge.

Case xxiv. A colored male, aged twenty-one, was admitted to the Graduate Hospital on July 2, 1928, with pain in the right hand. He admitted having gonorrhea in January, 1928. On June 26, 1928, the patient was exposed to damp weather and developed pain in the right wrist the following day. The patient suffered chills and fever. The left wrist became tender but did not swell. Subsequently the knees and right ankle became involved. Shortly all the joint symptoms subsided except in the right hand where pain and swelling progressed slowly. The blood Wassermann was negative. Urine was cloudy. Prostatic smears revealed no gonococci but contained an abundance of pus cells.

The roentgenograms of the right wrist taken on July 30, 1928, showed a general haziness of the carpal joints with blurring of the carpal bones. In practically all of the carpal bones there was noted a zone of rarefaction 1 mm. behind the articular cortex (Fig. 16). A clear cut story of a preceding gonorrhea helped establish the diagnosis of a specific arthritis.

Case xxv. A colored male, aged twenty-four, was admitted to the Graduate Hospital on September 10, 1925, with swelling of both hands. Three years previously he had a urethral discharge. Four weeks preceding admission he had burning and frequency on urination and his testicles became swollen and painful. Later his hands became stiff and painful, with swelling of the dorsum. Urethral smears were positive for gonococci.

Roentgenogram of the right wrist was negative except for moderate swelling of the dorsum. The left wrist showed haziness of the joint spaces and blurring of the carpal bones and articular margins. There was undoubted clinical evidence substantiating a diagnosis of gonorrheal arthritis.

Case xxvi. A colored male, aged thirty-eight, was admitted to the Surgical Dispensary of the Graduate Hospital on September 4, 1928, with swelling of the right wrist. On August 24, 1928, he developed a urethral discharge, following exposure. Pain in the right wrist began on August 30, 1928. The urine was cloudy in the two-glass test.

A roentgen examination of the right wrist, made on September 20, showed a spotty osteoporosis of the carpus. The joint spaces and articular margins were generally hazy. The adjoining metacarpal bases showed moderately advanced atrophy. The chronological relationship of an arthritis following a urethral discharge strongly suggested a specific etiology.

Case xxvii. A young white female, aged nineteen, came to the Orthopedic Dispensary of the Graduate Hospital on March 12, 1932, with right hip disease. Two and a half years previously she had an attack of gonorrhae

TABLE I

A PRESUMPTIVE SERIES OF GONORRHEAL ARTHRITIS SHOWING DEFINITE BONE AND JOINT PATHOLOGY. SELECTED FROM THE FILES OF THE UNIVERSITY AND GRADUATE HOSPITALS

Case No.	Age yr.	Color	Sex	Evidence of Gonorrhea	Site of Arthritis	Duration of Arthritis	Roentgen Pathology
I	19	White	F	Leucorrhea. History of gonorrhea. Positive gonococcal complement fixation test	Left hip	17 days on admission; 13 mo. at last examination	Ground glass atrophy; osteoporosis; erosion
II	46	White	M	History of gonorrhea. Urethral smear positive	Right hip	15 mo.	Ankylosis; erosion; chondrolysis
III	26	White	M	Positive gonococcal complement fixation test	Polyarthritis in beginning, localizing in rt. foot.	60 days	Spotty ground glass atrophy; fibro-osseous ankylosis; hazy joint spaces
IV	20	White	F	Salpingitis. Endocervicitis. Strongly positive comp. fixation test	Left ankle, rt. index finger	8 mo.	Ankylosis; spotty ground glass atrophy
V	30	White	M	Recurrent urethritis. Prostatic pus	Polyarthritis with localization in rt. wrist, left ankle and foot	6 yr.	Subluxations; atrophy; calcaneal spurs
VI	15	White	M	Urethritis after exposure	Right foot	25 days	Erosion; widened joint
VII	23	White	M	Gonococcal urethritis	Right foot and dorsal spine	1 yr.	Horizontal calcaneal spurs; osteophyte of spine
VIII	21	White	F	Leucorrhea	Left foot	4 weeks	Clouding and widening of joint; erosion
IX	27	White	F	Endocervicitis	Left ankle and foot	2 yr.	Spotting atrophy
X	24	White	M	Gonococcal urethritis	Both feet	4 yr.	Calcaneal spurs; ankylosis; atrophy
XI	22	White	M	Gonococcal urethritis. Gonococcal comp. fixation test positive	Both feet	4 mo.	Spotty ground glass atrophy
XII	21	White	F	Endocervicitis	Left elbow	2 mo.	Synovitis; osteitis; ankylosis
XIII	28	Black	M	Gonococcal urethritis	Right elbow	4 mo.	Hazy and narrowed joints; synovitis; osteoporosis; osteitis; ankylosis

Table I (*Continued*)

Case No.	Age yr.	Color	Sex	Evidence of Gonorrhea	Site of Arthritis	Duration of Arthritis	Roentgen Pathology
XIV	17	Black	F	Vaginal discharge following intercourse	Right knee	4 wk.	Erosion; synovitis
XV	33	White	F	Gonococci found in urethral and vaginal smears. Miscarriage	Polyarthritis localized in rt. knee	4 wk.	Synovitis; widened joint
XVI	18	White	F	Vaginal discharge following intercourse. Gonococci found in knee aspiration	Left knee	9 days	Synovitis; indistinct articular margins
XVII	46	Black	M	Gonococcal urethritis. Positive gonogoccal comp. fixation test	Left knee	2 mo.	Osteoporosis
XVIII	27	White	F	Pelvic inflammatory disease	Right knee	1 mo.	Erosions; synovitis
XIX	28	White	F	Vaginal discharge	Left knee	18 mo.	Ground glass atrophy; chondrolysis; osteitis
XX	47	Black	F	Miscarriages	Both knees	15 yr.	Exostosis; atrophy
XXI	23	White	M	Gonococcal urethritis	Both wrists and elbows	6 mo.	Atrophy; ankylosis
XXII	19	White	F	Genital smears positive for gonococci	Polyarthritis localizing in left wrist	25 days	Synovitis; ground glass atrophy; hazy joint spaces
XXIII	21	White	F	Vaginal discharge	Left wrist	2 yr.	Atrophy; spotty decalcification
XXIV	21	Black	M	Gonococcal urethritis	Right wrist	1 mo.	Hazy joint space; blurring of trabeculations
XXV	24	Black	M	Gonococcal urethritis	Both wrists	2 wk.	Synovitis; hazy joint space; trabecular blurring articular margin
XXVI	38	Black	M	Gonococcal urethritis	Right wrist	4 wk.	Osteoporosis; hazy joint spaces; atrophy; blurred articular margins
XXVII	19	White	F	Gonococcal urethritis	Right hip	2½ yr.	Osteoarthritis

which was shortly followed by pain in the right hip.

A roentgenogram of the right hip showed an osteoarthritis and a narrowing of the joint space. On each side of the joint there was a reactive zone of osteitis about 4 mm. in width.

The second roentgen examination on May 3, 1932, showed no appreciable changes. The diagnosis of gonorrheal arthritis was clinically supported by the history of an old gonorrhea with an associated arthritis.

A DIFFERENTIAL SERIES OF NON-GONOCOCCAL ARTHRITIS

Case A. A white male, aged fifty-two, came to the Orthopedic Dispensary of the University Hospital on August 16, 1932, complaining of right elbow pains. He was found to have an advanced bilateral pulmonary tuberculosis. Elbow symptoms began in July, 1932. There was no history or laboratory data obtained that would indicate a gonococcal etiology. The clinical diagnosis was tuberculous arthritis.

Roentgen examination on August 17, 1932, revealed a destructive arthritis involving the right elbow joint. There was ground glass atrophy of the humerus, radius, and ulna in the region of the joint. The articular cortex had been destroyed and the joint spaces were narrow. There was a zone of reactive osteitis on the posterior border of the olecranon process (Fig. 17). Re-examination on September 28, 1932, showed a progression of the destructive process. A third examination on November 16, 1932, showed further progression of the destructive tendencies with ragged flaring of the coracoid process. The appearances in the case suggested an acute infectious arthritis, probably of gonorrheal origin, but the clinical evidence strongly favored a tuberculous etiology. In view of the tuberculous nature of this joint, it was interesting to note the reactive osteitis found in the ulna. A fourth examination on January 11, 1933, showed multiple rarefactions in the soft tissues of the joint having the appearance of air, probably the result of hydrogen peroxide dressing on an open wound. Ankylosis of the humerus and ulna appeared to have taken place (Fig 18).

Fig. 17. Case A.

Dr. H. K. Pancoast brought out the interesting observation that the ulna is the only long bone which will give new bone formation in the neighborhood of a tuberculous joint. This occurs in the upper end and when the bone itself is obviously involved.

Case B. A colored female, aged thirteen,

was admitted to the Orthopedic Dispensary of the Graduate Hospital on April 15, 1932, with swelling of the knees. Knee symptoms began several months previously unassociated with any pain. Increased swelling followed with pain and stiffness. Vaginal smears were negative for gonococci. Blood Wassermann was negative. Mantoux reaction was positive.

Roentgenographic examination on April 18, 1932, showed moderately advanced decalcification bilaterally of the knee bones. The interarticular spaces were preserved. In the metaphysis of the tibiae were found spotty atrophic areas. Re-examination on March 17, 1933, showed moderate progression of the atrophic changes with no articular destruction. Tuberculosis was considered to be the etiological factor.

Case c. A white female, aged fifty-nine, was admitted to the Cardiac Clinic of the Graduate Hospital, May 9, 1930. There had been an ache in the left hip for twelve months previously. Cardiac examination revealed the presence of arteriosclerosis and an enlarged heart with a relative mitral insufficiency. There was no gonorrheal history elicited. A vesicovaginal fistula was found. The tonsils were diseased. Blood Wassermann was negative.

A roentgenogram, taken on September 23, 1930, of the left hip, revealed narrowing of the joint space with a reactive osteitis in the acetabulum and femoral head. In both these regions were found multiple areas of ground glass atrophy. The course of events suggested a septic arthritis possibly of tonsillar origin (Fig. 19).

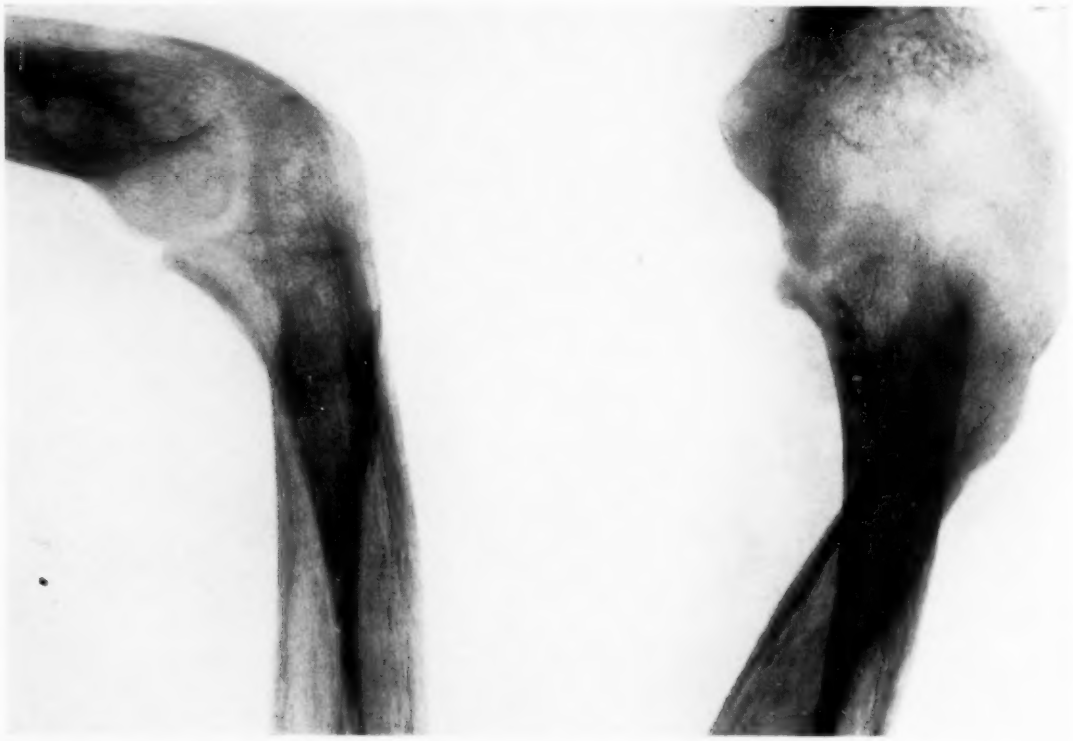

Fig. 18. Case a.

Case d. A white female, aged forty-six, came to the Surgical Dispensary of the University Hospital on August 20, 1928, with a discharging sinus of the right elbow. There was no history of gonorrhea.

A roentgen examination of the right elbow on September 6, 1928, showed the presence of a destructive arthritis. There was swelling of the soft tissues, ground glass atrophy of all the bones, erosion of the articular cortex, and a flaring of the coracoid process of the ulna. This was evidently an acute infectious arthritis (Fig. 20).

Case e. A white female, aged sixty, was admitted to the Graduate Hospital on June 22,

Fig. 19. Case c.

1931, with stiffness of the right hip beginning in 1926, which persisted. This was associated with a dull, aching, constant pain, aggravated by motion. The patient was found to have arteriosclerosis, hypertension, myocardial degeneration, and septic tonsils

A roentgenographic examination on June 3, 1931, disclosed an infectious osteoarthritis of the right hip. There was a wide zone of osteitis on both sides of the joint with flaring and migration upward of the acetabulum. There was some evidence of ankylosis (Fig. 21). The etiology was considered nonspecific.

Case f. A white female, aged twenty-three, came to the Orthopedic Dispensary of the University Hospital on August 17, 1932, with disease of the right hip. In 1926 the patient fell and suffered a dislocation of the right hip, which was reduced. In 1928 she began to have pain and impairment of function, which symptoms have persisted. The cervical and urethral smears were negative for gonococci. The complement fixation test was also negative. The tonsils were considered to be diseased.

Roentgenographic examination on August 17, 1932, showed narrowing of the joint space, multiple areas of ground glass atrophy, and flattening in the head of the femur. The trabec-

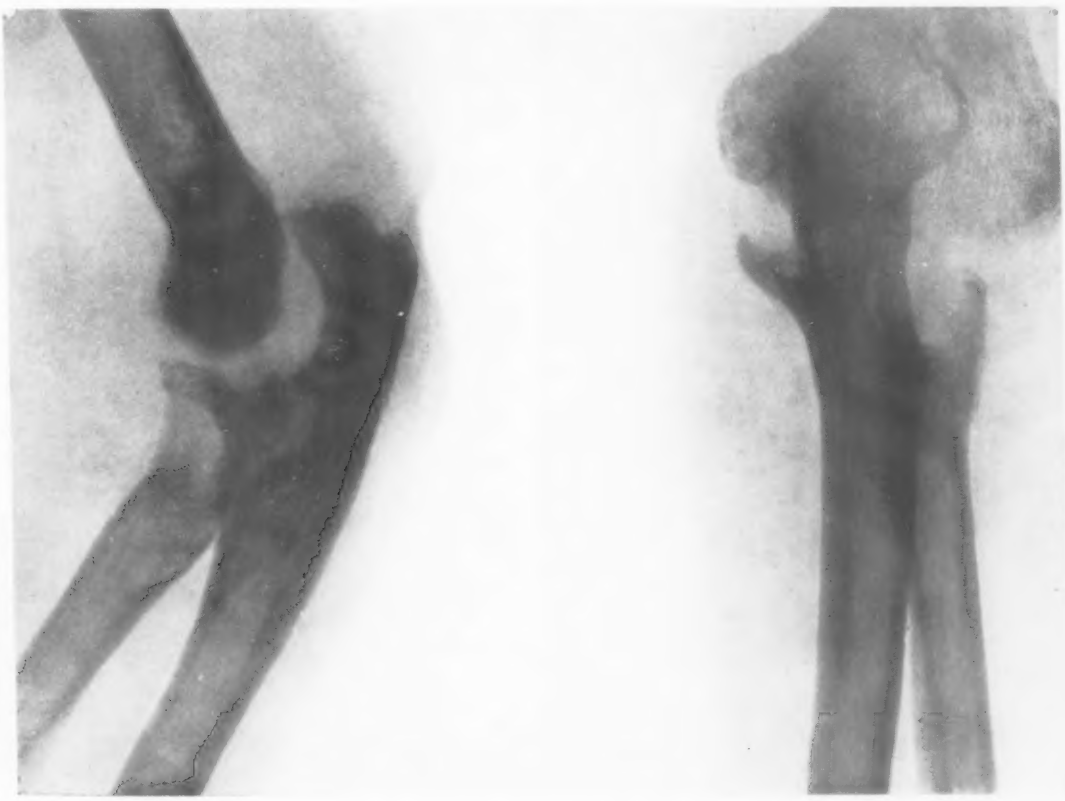

Fig. 20. Case d.

Fig. 21. Case E.

ulations in the femoral shaft were coarse and irregular. There was a moderate amount of decalcification extending from the greater trochanter downward (Fig. 22). Re-examination on March 1, 1933, showed further destruction of the femoral head. Coarse trabeculations with scattered areas of rarefaction extended down the right femoral shaft to the knee. There was a moderate decalcification in the head of the tibia. The left femur appeared normal but the head of the left tibia showed some decalcification. Both shoulder joints were normal. The bones of the wrists and hands were normal. A third examination of the right hip on May 12, 1933, indicated further progression with beginning fragmentation of the femoral head and a clouding of the joint space. The etiology in this case was undetermined (Fig. 23).

CONCLUSIONS

The present study indicates that gonorrheal arthritis yields a wide variety of roentgen appearances, varying from simple swelling of the soft parts to diffuse bony ankylosis, but in no wise presenting any features essentially specific. Finding honeycombed osteoporosis, spotty ground glass atrophy, or calcaneal exostoses should create a strong suspicion of gonococcal disease that must be clinically confirmed before a final diagnosis is rendered. Any case of arthritis arising in early adult life, from the ages of fifteen to thirty years, merits a careful search for present or past Neisserian infection.

Fig. 22. Case F.

Fig. 23. Case F.

TABLE II

A DIFFERENTIAL SERIES OF NON-GONOCOCCAL ARTHRITIS

No.	Age yr.	Color	Sex	Evidence of Gonorrhea	Etiology	Site of Arthritis	Duration of Arthritis	Roentgen Pathology
A	52	White	M	None	Tuberculosis	Right elbow	6 wk.	Ground glass atrophy; flaring—erosion; narrowing of joint
B	13	Colored	F	None	Tuberculosis (?)	Both knees	Several months	Ground glass atrophy; decalcification
C	59	White	F	None	Infectious arthritis	Left hip	18 mo.	Ground glass atrophy; osteitis; narrowing of joint space
D	46	White	F	None	Infectious arthritis	Right elbow	Unknown	Flaring; erosion; ground glass atrophy
E	60	White	F	None	Infectious arthritis	Right hip	5 yr.	Ankylosis; osteitis; flaring
F	23	White	F	None	Trauma (?)	Right hip	6 yr.	Ground glass atrophy; fragmentation; coarse trabeculation; blurring of joint space

SUMMARY

1. There are no specific roentgen signs pathognomonic of gonorrheal arthritis, but the roentgenogram may render valuable assistance in making a clinical diagnosis.

2. Clinical and pathologic alterations in gonorrheal arthritis are allegedly nonspecific.

3. Roentgen study is a valuable adjunct in guiding the treatment of gonorrheal arthritis.

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PRIMARY HEMANGIOMA OF THE THIRD LUMBAR VERTEBRA

CASE REPORT

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IT HAS been stated by Makrycostas[4] and Töpfer[8] that primary hemangioma of the vertebrae is very common at the necropsy table, but that in very few instances are the signs and symptoms sufficient to establish a clinical diagnosis. Bucy and Capp[1] reported 11 cases which produced symtoms of compression myelitis. Angioma of the bone is recognized by the Bone Registry of the American College of Surgeons as a definite entity, and 9 verified tumors are recorded in their collection. Fibiger,[2] Pentmann,[5] Makrycostas,[4] and Saltykow,[7] have reported 14 cases without symptoms. In these cases frequency in females as compared to males was about two to one. All age groups have been included among the reported statistics. The absence of symptoms can be attributed to involvement of the vertebral bodies only. Töpfer[8] sectioned the vertebrae in 2,154 cases at autopsy and found hemangioma in 257 (11.93 per cent). In 34 cases the involvement was multiple, in 4 the lesion was in the spinous processes, and in 3 in the arch. All these cases were without symptoms.

The lesion is usually in the mid-dorsal region, occasionally the upper and lower dorsal and lumbar vertebrae are involved, but there is no report of lesions in the cervical spine. Signs and symptoms when present are indistinguishable from those produced by spinal cord tumor. According to Perman[6] and Gold[3] the roentgenograms are characteristic and a diagnosis should be made upon the roentgen findings which consist in irregular absorption and thickening of the remaining vertical trabeculae with resulting parallel vertical striations in the body of the vertebrae, and loss of homogeneous bony structure.

The case presented is of interest because it occurred in an adult male about thirty-eight years after injury, because the symptoms of compression myelitis were absent,

FIG. 1. The lumbar spine examination shows roentgenographic evidence of a hemangioma of the third vertebral body. This is characterized by a decrease of the total density of the vertebral body and the formation of vertical striations.

and because characteristic roentgen findings made a clinical diagnosis possible.

F. D. G., a physician, aged forty-four, was admitted to the hospital for treatment of osteoarthritis (rheumatoid).

Chief Complaint. Low back pain.

TABLE I
ROENTGEN TREATMENT

Region Treated Lumbar spine	Skin Dose	Voltage	Filter	Target-Skin Distance	Size Field cm.	Current	Time min.
Posterior	850	200	0.75	60	8×8	30	34.0
Anterior	906	200	1.00	60	6×6	30	43.6

Family History. Essentially negative.

Past History. States that when a child another boy fell on him injuring his third lumbar vertebra. He wore a plaster cast for six months. Following this treatment there were no symptoms for many years. He was able to play football while in college.

Present Illness. In 1921 pain suddenly developed in various joints at intervals. His condition was diagnosed rheumatoid arthritis, including the spine, which diagnosis he has carried since 1921. In 1932 an acute cystitis appeared suddenly followed by chronic prostatitis. The condition cleared in about two months.*

Physical examination reveals a well developed and nourished male who is not acutely ill. The posture is erect, gait is normal, and there is no evidence of neuroses or nervousness. There is no evidence of gibbus. Motions in the spine are done to normal range without pain. On deep palpation and fist percussion there is some tenderness along the lumbar spine, especially the third, and the sacroiliac joints. Fifty per cent limitation of motion in abduction and flexion in the right hip is due to arthritis. There are no neurological findings.

Laboratory Findings. Erythrocytes, 5,100,000; white blood cells, 8,600; differential: polymorphonuclear leucocytes, 70 per cent; small mononuclear leucocytes, 24 per cent; large mononuclear leucocytes, 4 per cent; eosinophiles, 1 per cent; basophiles, 1 per cent; hemoglobin, 85 per cent. Urinalysis, negative. Wassermann and Kahn reactions, negative.

Roentgen Findings. The lumbar spine shows in the body of the third roentgenographic evidence of a hemangioma of the vertebral body. This is characterized by a decrease of the total density of the vertebral body and the formation of vertical striations.

Roentgen Treatment. There was considerable reaction to the first roentgen dose but very little to the second.

* Note the absence of symptoms referable to the third lumbar vertebra.

SUMMARY

1. Hemangioma of the vertebrae is a rather common finding at necropsy (11.93 per cent).

2. Due to absence of symptoms a clinical diagnosis is uncommon.

3. Signs and symptoms when present are indistinguishable from those produced by spinal cord tumor, i.e., compression myelitis.

4. Characteristic roentgen findings afford the only means of making a clinical diagnosis.

5. A non-symptomatic case is reported involving the third lumbar vertebra, with characteristic roentgen findings.

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PELLEGRINI-STIEDA'S DISEASE

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REPORTS of Pellegrini-Stieda's disease have appeared from time to time in the foreign medical literature with only an occasional report in the American literature. This disease is recorded for the following reasons: (1) it is probably more prevalent than is suspected; (2) the disease should be considered in all knee joint derangements which present negative roentgen findings immediately following an injury; (3) immediate post-traumatic and follow-up roentgenograms are essential for the diagnosis, and (4) it is important from a medicolegal aspect.

The disease has a typical clinical history in which there is evidence of slight or severe trauma to the knee joint. The pain in most cases is slight but disabling in character. The mechanism of the trauma is such that it would produce internal derangement of the knee joint. There is no history of locking or definite limitation of motion but these patients have some difficulty in going upstairs. On examination one finds an area of tenderness on pressure over the internal condyle of the femur. The range of motion is limited because of pain. There may or may not be any evidence of swelling but in most cases there can be palpated a firm mass over the internal condyle which is not attached to the skin. This mass appears about one to two months after the injury and can be definitely confirmed by roentgen examination.

In the review of the literature, it will be noted that Pellegrini in 1905 published a complete report of paracondyloid ossification following an injury to the knee joint. He believed that two factors played a rôle in its production, one, a periosteal proliferation directly connected with the medial femoral condyle and second, that an osseous metaplasia of the ligaments took place. In 1908 Stieda reported on the pathogenesis of this formation. He felt that it was always associated with a fracture of the medial epicondyle of the femur and there was a tearing of the muscle attachments. This pathogenesis was supported by Pfister, Preiser, and others. Ewald in 1913 believed that there was an extravasation of blood and synovial fluid into the internal lateral ligament which ultimately led to calcification. Schüller and Weil, in 1923, believed that the contusion was the exciting factor in producing a metaplasia of the connective tissue. Freund in 1933 gave an excellent pathological description in which he stated that there were three different types of bone growth: (1) a primitive infiltrative bone growth on the basis of connective tissue; (2) bone formation which is similar to callus formation, and (3) an endochondral formation of bone.

There is no doubt that all of the authors mentioned have felt that this mass is of traumatic origin. A so-called strain or tear of the internal lateral ligament might be the primary factor in producing this osseous mass. It is generally accepted that under certain stimuli connective tissue can assume embryonal appearances and by metaplasia, form bone. From the appearance of our roentgenograms, the mass is paraosteal and it is assumed that it was produced by a metaplasia of the internal lateral ligament of the knee joint. If our assumptions are correct then we can favorably compare this condition to myositis ossificans. Kulowski has clearly shown that this relationship is highly probable.

In 1905 Köhler was the first to describe roentgenologically a mass which had a paracondyloid situation on the inner aspect of the knee joint. Some authors believe that there is present first an epicondyloid fracture while others feel that there is a metaplasia of the connective tissue. We believe that there need not be any fracture present for the production of ossification of the in-

Fig. 1. Case A. G. Epicondyloid fracture of the left femur.

ternal lateral ligament, but a fracture may be present. In the case of A. G., a definite fracture of the internal epicondyle of the femur was present (see Fig. 1). This case was followed for three months for any evidence of ossification of the paraosteal tissue. At no time was there any evidence of increased callus formation or ossification of the paraosteal tissue. After three months there was no union of the fragment and roentgen examination showed no difference in the bony structures as compared with the first roentgenograms. In the case of S. M., the patient sustained a slight trauma to the inner aspect of the knee joint and began to complain of a mass which was developing about two months after her injury. At first her attending physician did not deem the injury severe enough to warrant a roentgen examination. However, after two months she came under our observation and a definite mass was palpated. The roentgenogram at this time revealed a mass 2.5 × 1.5 cm. situated in the internal lateral ligament of the femur. There were areas of increased and decreased densities which can be explained by the pathological findings of Freund. This mass was compared with an early callus formation at a site of fracture and the resemblance is striking. One month later another roentgenogram was taken which showed the mass to be decreased in size and there was evidence of increased density. This can be explained by the fact that ossification has been complete (Figs. 2 and 3).

CASE REPORTS

Mrs. S. M., aged forty-five, complained of pain and discomfort in walking upstairs. She

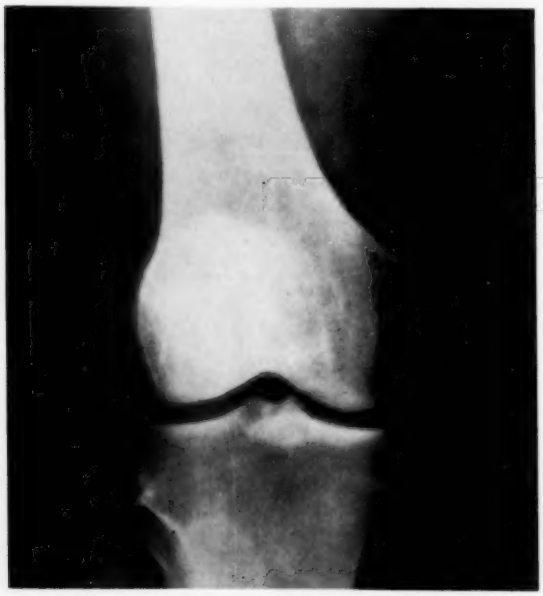

Fig. 2. Case S. M. Showing the paraosteal ossification at the end of two months.

Fig. 3. Case S. M. Showing the paraosteal ossification three months following the injury.

also stated that a nodule was felt on the inner aspect of the right knee joint. The onset of the complaints was following a direct trauma to the right knee. The mechanism of the injury was typical of one that would produce internal derangement. The patient stated that at the onset of the trauma a sharp pain was experienced which subsided after a few days and became dull in character. The pain was constant and was aggravated by walking. Weather changes had no effect upon the condition. There was no history of locking or sense of weakness in the knee joint. About two months after the injury a mass was felt by the patient. During the first two months the patient stated that she was receiving "lamp" treatments which did not cause any improvement. The past history was negative.

Examination of the patient revealed a well-developed white female who did not appear to be in pain or distress. The right knee joint revealed the only pathology. The patient walked with a slight right-sided limp and the right knee was held in extension when going upstairs. Measurements revealed a half inch difference in circumference as compared to the left. Range of motion of the right knee joint showed a loss of complete extension of 10° and flexion was possible for 85°. Passive motion beyond the above range caused pain. A small walnut-sized mass was felt on the inner aspect of right knee joint which was situated about 1 inch above the articulating surfaces. There was pain on deep pressure. The mass felt firm and was fixed to the underlying structures. When the internal lateral ligaments were put at a tension pain was experienced in the region of the mass.

The roentgen findings two months after the onset of symptoms revealed a mass situated in the paraosteal structures of the right knee joint. The bone markings of the femur were clearly outlined and showed no irregularities. The mass on the first examination did not reveal a uniform density. One month after the first roentgen examination, or three months after the injury, the mass was smaller and there was a more or less uniform density.

The patient was given daily deep diathermy treatments and an elastic bandage for support to the right knee joint. After three weeks of treatment the patient was free of symptoms. She was last seen six months after the initial symptoms and was free of all pain and discomfort.

Mr. A. G., aged forty-eight, complained of marked pain and discomfort in the left knee joint immediately following a fall. The mechanism of the injury was a direct blow to the inner aspect of the knee. Examination revealed a well-developed white male who appeared to be in acute pain. The only pathology found was a bruise in the region of the inner aspect of the left knee joint. There was definite limited motion because of pain. A local point of tenderness was elicited over the internal epicondyle of the femur. A roentgenogram of both knee joints revealed a typical epicondyloid fracture of the left femur. Roentgenograms taken at intervals of three weeks for three months showed no calcification of the internal lateral ligament (see Fig. 1).

SUMMARY

A case of Pellegrini-Stieda's disease is reported and compared with an epicondyloid fracture. It is felt by the authors that a fracture of the internal condyle of the femur may or may not be present in the above condition. Also, that the ossification is due to a metaplasia of the connective tissue.

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THE BIOLOGICAL EFFECTS OF ROENTGEN RAYS ON *PLANARIA DOROTOCEPHALA*

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IN THIS experiment 400 *Planaria dorotocephala* 10 to 15 millimeters in length were selected from a stock supply collected near Lake Zurich, Illinois. The animals were kept in the laboratory for four weeks preceding the experiment and were then placed in 500 c.c. Erlenmeyer flasks to which was added 250 c.c. of lake water. These flasks were kept in a tray of running water throughout the experiment with a temperature average of 18° C. Water was changed daily. The *Planaria* were irradiated in groups of 100 which were placed in a glass dish, the water drained off and the worms then anesthetized with iced carbonated water which was piped off before the exposures began. Twenty-four hours after exposure the heads and posterior zooids were cut off. The animals were then set up in groups of two flasks with 25 worms each and one flask of 50 worms. Controls were run for each.

In irradiating the worms no filter was used. All except the controls were given doses of 4, 8 and 12 skin units. Time was the variable factor in measuring the different doses. The peak was 95–100 kilowatts and the distance between the worms and the target was 15 inches. In group A of 4 skin units the time of exposure was ten minutes; in group B of 8 skin units the time was twenty minutes, and in group C of 12 skin units the time was thirty minutes. No examinations necessitating the transfer of the worms from the flasks were made until thirteen days after exposure. At this time each worm was examined with a binocular microscope to determine the degree of head formation. Relative length of life in different populations and in different dosages was also determined.

In Table I the following results are apparent: In all irradiated *Planaria* exposed to 4, 8 and 12 skin units, blunt-headed forms are the predominating type regenerated thirteen days after irradiation in both the groups of 25 and 50. It is possible to make only a general correlation between the strength of the dosage and the extent of head development thirteen days after irradiation. At this time there is no consistent advantage due to crowding. The rate of head development is apparently not affected by exposure to 4, 8 and 12 skin units. Disintegration does not occur during the first two weeks either in the irradiated forms or the controls.

In Table II the following changes are detected: At the end of three weeks correlation between the strength of the dosage and the degree of harmful effects is apparent, i.e., the stronger the dosage, the greater the number of headless forms appear. In forms exposed to 4, 8 and 12 skin units, the group of 50 shows an advantage over the group of 25. However, in groups having had 8 skin units the group of 25 had fewer headless forms than the group of 50. *Planaria* exposed to 4, 8 and 12 skin units show a loss of regenerated tissue without visible signs of cytolysis. This loss occurs during the third week after irradiation. The controls give no evidence of such change. Resorption or disappearance of newly regenerated tissue occurs among all the irradiated forms, even in those which regenerated normal heads and showed no morphological evidence of deleterious effects during the first and second week after exposure.

In Table III it can be seen that in all irradiated forms the number of headless forms has increased considerably from the twenty-first to the twenty-fifth day after exposure. The stronger the dose, the more pronounced the effects. At this stage the effects are less pronounced in the groups of 25 than in the groups of 50 for all doses.

TABLE I

FORMS REGENERATED THIRTEEN DAYS AFTER EXPOSURE TO 4, 8 AND 12 SKIN UNIT DOSES EXPRESSED IN PERCENTAGES

Groups	Dose	Normal	Blunt	Tera-toph-thalmic	Tera-to-morphic	Anoph-thalmic	Head-less	Disinte-grating	Totally disin-tegrated
Two flasks of 25 each for each dose	4	8	62	24	6				
	8		80	18	2				
	12		74	16	6	4			
Control		100							
One flask of 50 each for each dose	4	14	70	12	4				
	8		68	28	2				2
	12	2	70	26	2				
Control		94		4			2		

TABLE II

HEAD FORMS TWENTY-ONE DAYS AFTER EXPOSURE TO 4, 8 AND 12 SKIN UNIT DOSES EXPRESSED IN PERCENTAGES

Groups	Dose	Normal	Blunt	Modi-fied Blunt	Tera-toph-thalmic	Tera-to-morphic	Anoph-thalmic	Head-less	Disin-tegrating	Totally Disin-tegrated
Two flasks of 25 each for each dose	4	2		34	4	4	8	48		
	8		2	24		8		64	2	
	12			18		4	2	76		
Control		100								
One flask of 50 each for each dose	4		10	34	2	6	4	42		2
	8			20	2	4	4	68		2
	12		2	18	2	8	2	68		
Control		92			4	2				2

TABLE III

HEAD FORMS REGENERATED TWENTY-FIVE DAYS AFTER IRRADIATION EXPRESSED IN PERCENTAGES

Groups	Dose	Normal	Blunt	Modi-fied Blunt	Tera-toph-thalmic	Tera-to-morphic	Anoph-thalmic	Head-less	Disin-tegrating	Totally Disinte-tegrated
Two flasks of 25 each for each dose	4		6	18	4			72		
	8		4					96		
	12		2				4	82	2	10
Control		100								
One flask of 50 each for each dose	4		6	10	2	2		72		8
	8			6	2			88		4
	12			8				88		4
Control		92			4	2				2

There is a progressive increase in the number of disintegrating forms among all the irradiated animals between the twenty-fifth and the thirty-fourth day after exposure. The percentage totally disintegrated is proportional to the strength of

the dosage, increasing as the dosage increases. The percentage totally disintegrated is inversely proportional to the degree of crowding, the percentage being less in the groups of 50 than in the groups of 25 for all doses except for 8 skin units where the percentage is the same. The advantage of the group of 50 over the group of 25 is greater in forms treated with 12 skin units than those treated with 4. Swelling at the anterior and posterior ends is characteristic of almost all the irradiated forms at this time. In the headless forms there is a dark pigmented band just back of a narrow white and somewhat frayed margin. Similar markings sometimes occur along the sides. In some cases the posterior end is more affected than the anterior. New heads of the controls on the thirty-fourth day were a dark tan in color whereas no pigment had been deposited in the heads of the irradiated forms. All animals in the group of 50 that had been exposed to 12 skin units were dead thirty-four days after exposure.

On the thirty-eighth day all forms were dead that had been exposed to 8 and 12 skin units. Thirty-nine days after exposure those exposed to 4 skin units were all dead except 8 per cent.

CONCLUSIONS

1. In *Planaria dorotocephala* regeneration of heads may take place before the full effects of roentgen irradiation are evident. Regenerated heads of irradiated animals have normal eyes and auricles in many cases but they are only one-half to one-fourth the length of the heads of the controls. Regeneration proceeds in both the irradiated forms and in the controls.

2. The difference in the effect of 4, 8 and 12 skin units becomes more apparent after the first two weeks.

3. During the third week the animals begin to swell at the anterior end and the absorption of tissue begins to take place.

4. Resorption and loss of tissue are followed by a progressive cytolysis which affects the anterior end first.

5. The groups of 50 do not show significant survival value over the groups of 25.

6. The differences in the effects of different dosages of roentgen rays are quantitative.

7. The variations in head forms regenerated in groups of *Planaria* treated with 4, 8 and 12 skin units are similar to the head forms induced by various toxic agents, anesthetics and other conditions that affect the physiological state of the regenerating tissue.

8. Pigment was not deposited in any of the regenerated tissue of the irradiated forms, even in those which had been exposed to only 4 skin units and that survived forty-two days after irradiation.

9. The effects of 4, 8 and 12 skin units on planarian tissue may be divided into three successive stages: (*a*) During the first two weeks cell division and cell differentiation are both affected. The indications are that cell division is the more affected. Rate of regeneration is not appreciably affected. (*b*) During the next ten days a resorption of tissue or a disappearance of the newly regenerated tissue takes place. During this period the animals are extremely sensitive to any object in their path. (*c*) During the fourth week there is a progressive disintegration of tissue beginning at the anterior end. The rate of disintegration is in proportion to the strength of the dose. The animals are very inactive during this period.

10. Crowding varies only the rate of the successive changes ascribed to the effects of roentgen rays.

11. The benefits of crowding become more apparent as the dose of roentgen rays is increased.

12. The effects of crowding in the above experiment are not consistently in favor of the groups of fifty.

Dr. C. A. Matthews irradiated the animals used in this experiment.

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THE DANGERS OF ROENTGENOSCOPY AND METHODS OF PROTECTION AGAINST THEM

IV. A DETAILED CONSIDERATION OF THE DOSES RECEIVED BY THE FINGERS OF THE EXAMINER*

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IN A previous paper we discussed the quantities of roentgen rays received by the hands of the roentgenoscopists of The Mayo Clinic, and stated that, in spite of lack of protection, except that offered by a leather driving glove, these men sustained no apparent injury whatever even from multiple doses of the accepted "tolerance" doses. We also pointed out the difficulties of reconciling with each other the quantity estimates of the doses as measured photographically and iontoquantimetrically. In this paper we will discuss in greater detail the doses administered to the fingers, which have been tolerated with no evident injury. In this connection we would like to emphasize again that we advocate no change in the accepted methods of protection until further study of the limits of safe dosage definitely indicates a change in them.

As we have stated, for the average examination lasting one and a half minutes the time is divided as follows: esophagus and cardiac opening, five seconds; mucosal relief, fifteen seconds; exploration of the lesser curvature, twenty seconds; filling duodenum, forty-five seconds; duodenal relief, five seconds. The technique of this examination was illustrated in our paper 1 of this series.[1] This we believe to be a fair estimate of the procedures in use at the Clinic. The beam is often much larger than 10 cm. square and frequently is smaller, but we consider a 10 cm. beam to represent a fair average of the sizes employed.

In each case, a percentage of the dose of roentgen rays delivered to the patient's back reaches the finger tips of the roentgenoscopist. By averaging these percentages, as measured for the positions described in the foregoing, we arrive at 0.557 per cent of that amount. The erythema dose of 400 r is delivered to the patient's back in twelve minutes and forty-eight seconds, which amounts to 11.7 per cent of an erythema dose to his back for each one and a half minutes' examination, provided the examiner works with a 5 ma. tube current. At the same time, if he is working with a 5 ma. tube current, the examiner receives 0.0652 per cent of an erythema dose to his finger tips for each examination. If, as is usually the case, he works with a 4 ma. current, he receives 0.0521 per cent of an erythema dose at each examination.

Since only the finger tips reach a depth of 5 cm. in the patient's abdomen, we must next establish the dose received by the palm and the proximal three-fourths of the fingers. One of the secrets of efficient roentgenoscopic palpation lies in the angle at which the fingers meet the plane of the patient's abdomen (Fig. 1). Close observation

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* Abstract of thesis submitted by Dr. Cilley to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Radiology.

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reveals that the fingers are flexed somewhat at the joints, and considerably flexed on the palm, making the angle they present to the central ray of the beam of roentgen rays used in examination between 70° and 90°. If the majority of the rays which reach the palpating fingers are traveling in the general direction of the central ray, which seems reasonable in view of the fairly clear image which examined objects cast on the screen, the fingers, with increasing angulation to the beam of rays, should receive progressively fewer rays, resulting in a smaller total dose per unit area. This theory was verified photographically .

The phantom was set up, a large beam used, and a group of test films were exposed to 6.10^{-4} S.E.D. in the direct beam. The films were arranged in groups, one group flat on the surface of the phantom, another group at an angle of 45° to the surface of the phantom, and a third group at an angle of 72.5° to the surface of the phantom. These films were exposed simultaneously and processed with other test films and a group of standard films exposed to known dosages. The densities were measured by means of the Cenco-Sheard-Sanford photelometer, and the dosages received were thus compared. It was found that the films exposed at angles of 45° and of 72.5° registered half and a third, respectively, of the dosage registered by the films exposed flat on the wax. The experiment was repeated; this time strips of wax, 2 cm. thick, for the purpose of furnishing back-scattering comparable to that furnished by the fingers, were placed against the backs of the test films. These films, processed with and compared to another group of standard films in a similar manner, revealed the same variations in density.

From these experiments we felt justified in concluding that the proximal three-fourths of the palpating fingers, by virtue of the angle at which they meet the examining beam, must receive only a third of the dose per unit area which they would receive if exposed in the manner of the finger tips and the palm perpendicular to the path of the rays. Not only are the fingers protected by virtue of their angulation, but the main portions of the fingers never reach the 16 cm. depth, and are also somewhat screened by the surrounding barium. Consequently, it seems conservative to consider that the proximal three-fourths of the fingers receive a third of the dose estimated

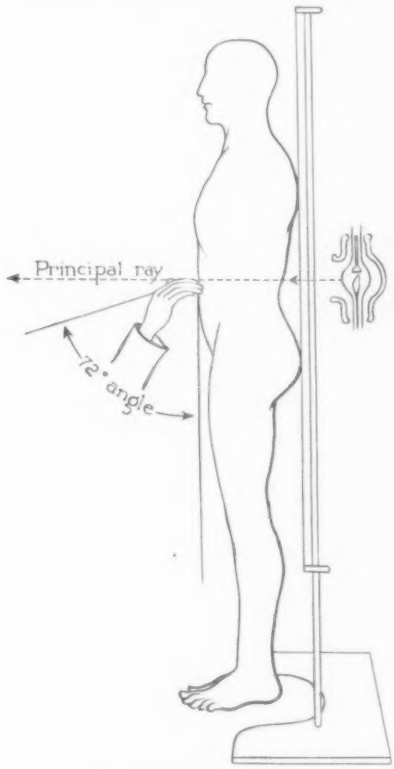

FIG. 1. The angle formed by the palpating fingers and the anterior abdominal wall. It is this angle which reduces the dosage received by the proximal three-fourths of the fingers to one-third of the dosage delivered at the same distance in a plane parallel to the anterior abdominal wall.

for the finger tips. Therefore, the proximal three-fourths of the fingers may be said to receive 0.0217 per cent of our erythema dose at each examination if a 5 ma. tube current is used, and 0.0173 per cent of our erythema dose if a 4 ma. current is used.

The palm of the hand seldom enters the direct beam except during exploration of the mucosal relief. Consequently, consulting our test cases, a new dosage for the palm must be estimated. Since the palm is

well away from the beam, with the full thickness of the stomach between it and the beam, the dosage received during exploration of the lesser curvature may be reduced to that fraction. Conditions are relatively unchanged during filling of the duodenal cap. During exploration of the mucosal relief, due to the angle of the palpating fingers, the palm remains shielded by the full thickness of the body, granting, as may be the case in this procedure, that the whole hand is exposed in the shifting beam. Considering these factors, the estimate of dosage for the palm becomes 0.158 per cent of the dose at the back board of the roentgenoscope. In other words, the palm receives 0.0184 per cent erythema dose at each examination if a 5 ma. tube current is used, or 0.0123 per cent erythema dose for each minute of examination. Based on the usual 4 ma. tube current, the dosage becomes 0.0147 per cent erythema dose for each examination (Tables I and II).

When it came to actual exposure of the films destined to form the standard series, a number of questions arose. In the interest of reasonable accuracy, should the films be exposed in air or in contact with wax, to furnish back-scattering comparable to that from the hand or body of the operator wearing the test films? If this back-scattering made any marked difference in opacity of the films, as seemed reasonable in view of common experience with ionization chambers, in which case the dose is increased from 5 to 60 per cent by back-scattering, depending on such factors as the size of the field and the wave length used, then the films should be so exposed. A series of films was exposed with the object in view of answering these questions. The wax phantom was set up at a distance of 5 feet from a roentgen tube, in a horizontal holder, so that the top of the wax was several inches below the horizontal plane of the cathode of the tube, and its center was

Table I

Computation of palm and finger tip dose based on 5 ma. tube current

Position	Fingers			Palm		
	Seconds	Depth dose, per cent	Total, r	Seconds	Depth dose, per cent	Total, r
Cardiac orifice	5	0.00	0.000	5	0.00	0.000
Mucosal relief	15	0.02	0.30	15	0.0067	0.1005
Exposure, lesser curvature	20	0.0048	0.096	20	0.00013	0.00260
Filling duodenum	45	0.00013	0.00585	45	0.00013	0.00585
Duodenal relief	5	0.02	0.10	5	0.0067	0.0335
			0.00185			0.14245
Dividing by 90 = average dose for procedure			0.00557			0.00158

Table II

Dosage (based on 5 ma. tube current) received by the three parts of the hand during examination

Part of hand	Depth dose, per cent	Per cent S.E.D. per examination	Per cent S.E.D. per minute
Finger tips	0.557	0.0652	0.0435
Proximal three-fourths of fingers	0.185	0.0217	0.0144
Palm	0.158	0.0184	0.0113

in the same vertical plane as the target. A dental film and a piece of 8 by 10 film were placed side by side against the phantom. Some 3 in. directly above these, and in the same plane, similar films were similarly placed against a strip of wax 1.5 cm. thick, to correspond to the back-scattering received from the operator's fingers. Two more films were suspended in air, by means of adhesive tape, about 3 in. above this second group. Thus the three pairs of films were so grouped that, particularly at this distance, they should be in a zone of homogeneous radiation. They were exposed to 30.10^{-5} S.E.D. and replaced by similar films that were exposed to 60.10^{-5} S.E.D. This exposure was measured by means of the large ionization chamber which was suspended several inches above the highest pair of films. The tube was actuated by 100 kv.p. and the rays were filtered by 3 mm. aluminum. The filter was next removed and the voltage was dropped 50 kv.p. This time two pairs of films were compared, one pair in air, the other against the 1.5 cm. of wax. They were exposed to 30.10^{-5} of an erythema dose as measured by the large chamber. Two other pairs were exposed against the wax, to 60.10^{-5} and 90.10^{-5} of an erythema dose. Lastly, the phantom was placed against the back board of the vertical roentgenoscope, a 24 cm. square beam was used, and similar pairs of films were exposed with 1.5 cm. wax backing, to 30.10^{-5} and 60.10^{-5} of an erythema dose; and without backing to 30.10^{-5}, 60.10^{-5}, and 90.10^{-5} of an erythema dose, as measured by the large ionization chamber. (The foregoing fractions of erythema doses are based on 400 roentgens as an erythema dose.) Next, similar pairs of films were exposed with and without backing to 30.10^{-5} and 60.10^{-5} of an erythema dose, estimated on the basis of 600 r as an erythema dose, and measured by means of the large ionization chamber under the same three conditions of exposure. These films were all processed together and the opacities were measured by means of the photelometer. As the graphs made of these films showed clearly, the films irradiated against wax were darker than those irradiated in air, due to back-scattering. Further, the back-scattering was proportionately more marked in the more heavily irradiated films. As is the case with ionization chamber measurements the back-scattering increases the film density about a third also. The fact that back-scattering is about as marked on dental films, which are provided with lead foil backs, as on the paper-wrapped pieces of 8 by 10 films, indicates that the majority of these scattered rays have considerable penetrating power. The films exposed to 50 kv.p. should be considerably darker than those exposed to 100 kv.p., when the dosages they received were measured by the large ionization chamber, because of the effect of the aluminum walls of this chamber. The films thus exposed, using 50 kv.p. tension, were in fact darker to the extent of 2.10^{-4} S.E.D. than the films exposed using 100 kv.p. tension. For this reason, we determined to make the standard films for photographic measurements entirely independent of the ionization chamber measurements.

Four groups of films were chosen: three of these were dental films, and the fourth consisted of pieces of an 8 by 10 duplitized film. These films were taken to the Department of Roentgen Therapy and were exposed there on one of the carefully checked machines. An automatic timer calibrated in quarter seconds was installed for accuracy in exposing these films. Making use of a fixed diaphragm and the inverse square law to obtain a suitable intensity to read in the photelometer, the films were exposed to fractions of an erythema dose starting with 1.10^{-5} S.E.D., and proceeding at intervals to a maximal exposure of 5.10^{-3} S.E.D. The fractions of a S.E.D. separating the individual standard films were not always identical, since we deliberately chose intensities that could be measured accurately with our timer. Since the test films were to be evaluated by means of a graph, exact, orderly progression in intensity of the exposures of our standard films promised no advantage

TABLE III

FILM MEASUREMENTS OF DOSAGE RECEIVED BY THE HANDS OF THE OPERATORS

Operator	Organ examined	Number of examinations	Time of examination, minutes	Position of films in glove	S.E.D.
1	Colon	7	13	Second finger	0.001
	Colon	6	18	Second finger	0.001
2	Colon	4	9	Second finger	0.00048
	Colon	6	15	Second finger	0.00068
	Colon	31	78	Second finger	0.003*
	Stomach	20	34	Second finger	0.00036
	Stomach	14	20	Second finger	0.0002
3	Stomach	5	12	Palm	0.00217
	Stomach	22	34	Palm	0.0001
	Stomach	25	35	Palm	0.0015
	Stomach	30	42	Palm	0.0007
4	Stomach	10	22	Second finger	0.00068
	Stomach	9	23	Second finger	0.0007
	Stomach	12	24	Second finger	0.00068

* Films too dark for photo-electric measurement, compared visually.

TABLE IV

TOTAL DOSAGE TO OPERATORS' HANDS

Operator	Organ examined	Number examined	Time consumed, minutes	S.E.D.
1	Colon	13	31	0.002
2	Colon	41	102	0.00416
	Stomach	34	54	0.00056
3	Stomach	82	123	0.00247
4	Stomach	31	69	0.00206

TABLE V

AVERAGES OF THE DETERMINATIONS SHOWN IN TABLE IV

Operator	Organ examined	Time of examination, minutes	Average dose per examination	Average dose per minutes of examination
1	Colon	2.38	0.00015	0.000064
2	Colon	2.49	0.00010	0.000040
	Stomach	1.58	0.000016	0.00001
3	Stomach	1.52	0.00003	0.00002
4	Stomach	2.27	0.000068	0.000015

over the method we used. The groups of standard films were then exposed, four films at a time, against a wax block to afford proper back-scattering. The technique used was 100 kv.p., 2 mm. Al filter, target film distance 80 in. The timing was based on twenty-two minutes at a 16 in. target-skin distance as constituting an erythema dose.

We chose this technique for several reasons: the quality of rays thus produced corresponds well with that emanating from the phantom. Twenty-two minutes with this technique, at 16 in. target-skin distance, produces erythema in practically all cases, and discharges 615 r on our roentgenometer. It thus corresponds well with the erythema dose (5 H) of Holzknecht, suggested by many workers as consistent with the specifications of the safety committee.

The standard films and test films were differently marked, so that we knew which group of dental films and which pieces of each 8 by 10 film corresponded to each individual standard.

In practice, the test films were worn in the glove or affixed to the clothing of the physician in question, the time of exposure was noted through the use of the electric timing device, and, finally, the test films were processed and measured together with the appropriate standard.

Using the dental and 8 by 10 film standards made in the Section on Therapeutic Radiology, we obtained results that may be noted in Table III.

These measurements, although they reveal considerable variation, agree with surprising closeness when the variations in technique of examination demanded by the individual case are considered. For this reason, the total number of cases examined by each man, with the total dose, is summarized, and an average dose per examination is obtained by dividing the total dose by the total number of examinations. These average doses, shown in Tables IV and V, will be used in the computation of dosage received.

SUMMARY

Since it has been shown that the finger tips receive a dose of roentgen rays about three times as great as the dose to the rest of the hand, the emphasis placed on a palpatory technique which utilizes the smallest possible beam for the examination seems justified. The methods of measuring the quantities of roentgen rays received by the fingers which were used in this research lead to irreconcilable differences in results. Regardless of any measurements of quantity, it seems self-evident that a correct technique of roentgenoscopic examination is of basic importance in minimizing the injury received by the hand of the examiner.

ROENTGEN DERMATITIS TREATED WITH FRESH WHOLE LEAF OF ALOE VERA

By C. E. COLLINS, D.D.S., M.D.,
and
CRESTON COLLINS, M.S.
CRISFIELD, MARYLAND

REPORTS of a dermatitis peculiar to and incident to excessive exposure to roentgen rays began to appear a few years after the discovery of the roentgen rays was announced to the medical profession.

In many cases it has been shown that where there was reason to suspect only a short exposure to roentgen radiation in excess of the "tolerance" dosage, then the prompt application of ultraviolet appeared to counteract a percentage of the roentgen radiation. Pigmentation would, of course, result but morbid skin changes might be prevented.

By far the more numerous, however, have been those cases of workers in roentgenology, and patients who, because of improperly measured dosage, unanticipated hypersensitivity, or other reasons, have suffered from varying degrees of roentgen dermatitis, usually with a delayed reaction; and in a few instances from a permanent and possibly progressive destruction to underlying tissues.

It is because complete cures have been reported in so few of these severely burned cases that we think it worth while to record an evident cure in the following typical but not selected case:

REPORT OF CASE

A white woman, aged thirty-one was, on March 2, 1934, seen to be suffering with a severe roentgen dermatitis. There was desquamation over an area 4 by 8 cm. on the left side of the forehead, extending 2 cm. above the hair line. The history showed that in May, 1932, she had received (in another city) what she had been told was a depilatory roentgen treatment. Fourteen months later, she said, the skin of the forehead and scalp became rough and scabby and itched continuously (dermatitis exfoliativa). Between July, 1933, and March, 1934, she had successively consulted three physicians, all of whom had agreed as to the diagnosis, and who had prescribed (variously) boric acid, phenol in olive oil, ichthyol, a 5 per cent mercurial ointment, and zinc oxide. The condition had become progressively worse until there was (as has been stated) extensive desquamation with oozing of serous fluid. The patient stated that the itching and burning sensations were so severe and constant that she was compelled to wear cotton gloves at night in order to prevent scratching the damaged area and inducing bleeding.

After a review of this history and an examination of the condition it was felt that a skin graft was indicated and the patient was so advised. At the time of examination the patient was furnished with a quantity of aloe vera (fresh whole leaf) for local application, with the hope that this material might serve as a palliative (i.e., act to allay the itching). Twenty-four hours later she reported that the sensation of itching and burning had entirely subsided. She was instructed to continue the use of the plant material, and when seen from time to time during the next five weeks the condition was found to be progressively improved.

At the end of this time (i.e., on April 7, 1934), there was complete regeneration of the skin of the forehead and scalp, new hair growth, complete restoration of sensation, and absence of scar. There was at this time a slight blanching of the affected area. When last seen on July 23, 1934, the healed area appeared to be completely cured, with no indication whatever of a relapse. On exposure to the summer sunlight the skin of the forehead was seen to be pigmenting normally along with other exposed skin surfaces of the body.

COMMENT

The aloe vera leaf contains a large quantity of a light yellowish-green material having about the color and consistency of lemon jello; it is this intestine material which is used for local application. The

leaf may be split lengthwise or cut into thick cross-sections and the intestine material macerated. While this is still fresh, liberal quantities are applied to the area to be treated, covering it with a neutral, non-porous substance (such as waxed paper). Bandage or adhesive may then be used to secure the mass in place. An hour or two is the life of an application; it will then be found to be dark and gummy. It is simply washed off carefully with warm water, using no soap or medication. The applications may be renewed as often as may be desirable and convenient.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Publisher: Charles C Thomas, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich. Office of publication 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

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20th Annual Meeting: Atlantic City, N.J., June 10–11, 1935.

EDITORIALS

DIGESTIBILITY OF COMMON FOODSTUFF AS DETERMINED BY ROENTGEN EXAMINATION

THE digestibility of common foodstuff has been a source of considerable interest and investigation for these many years. We hear echoes of it from the Culinary Campaign of Alexis Soyer in the Crimean War and in the isolated army outpost in the Straits of Mackinaw in the experiments of William Beaumont. The real scientific study of the digestibility of foods began with the initial experiments of Beaumont performed on Alexis St. Martin. During the intervening years other investigators by means of tubes carried on experiments determining the emptying time of the stomach, but it remained for Rehfuss, Hawk and others to give a clear-cut scientific exposition of important facts about digestion in the normal stomach by the use of the Rehfuss tube. By this means they were able to determine the various types of gastric function and demonstrated that there was a fairly constant functioning of the stomach. They found that the functioning of the stomach was slow or fast depending somewhat upon the habitus of the patient, that the emptying time of the stomach depended also upon the kind of food swallowed and that the secretory response among healthy subjects could likewise be divided into groups, some showing a tendency to slow secretory output, others to a presumed normal, and still others to a hypersecretory type of response. One of the most significant features in their studies was the constancy of the type of gastric function. Individuals fall into definite groups and, barring all accidents or disease, an individual maintains his gastric type. In normal individuals the evacuation time of the stomach is dependent on the articles ingested and on the quantity of food. The average gastric digestion time is somewhere near four hours and rarely exceeds five hours. The gastric emptying time for the usual barium meal which the roentgenologist employs is from four to six hours, and the average is about four.

Not only have Rehfuss and his collaborators determined the emptying time of the stomach in normal individuals but Rehfuss[1] has carried out an extensive investigation on the digestion of meat, representing a protein, and potatoes, representing a carbohydrate, in a cross section of medical invalids ordinarily encountered in medical ward service, such as those suffering with gastric, cardiac, renal, hepatic, pulmonary and infectious diseases. In an investigation of 50 individuals suffering from the various chronic diseases, he found that 100 gm. of hamburger steak was digested in a little more than three hours and fifty-one minutes and that 100 gm. of hamburger steak with 100 gm. of mashed potatoes showed a general evacuation time of three hours and fifty-four minutes. As a result of his studies there was evidence to show that even in diseased individuals of markedly different types there is no incompatibility between protein and carbohydrate digestion and his studies emphasize the singular constancy of individual digestion as was emphasized in their studies on normal gastric function.

While the emptying time of the stomach has been studied so thoroughly by the Rehfuss tube method, and Cannon had previously carried out his classical x-ray studies on cats, roentgen studies on the emptying

[1] Rehfuss, M. E. Proteins versus the carbohydrates; an inquiry into their gastric digestion. *J. Am. M. Ass.*, 1934, *103*, 1600–1605.

time of the stomach for various foods in a series of healthy men and women has not been attempted until the recent studies of Maile and Scott,[2] perhaps due to the fact that the method is time consuming and requires considerable patience and some personal discomfort.

During the past two years Maile and Scott carried out a series of roentgen observations on the emptying time of the stomach on three doctors, their wives, a dentist and a medical student. Their ages varied between eighteen and forty-five, and all of those subjected to experimentation were healthy individuals with excellent digestion. The experiments were carried out while the subjects were going about their daily work in the usual manner. The test meals were usually given in the morning when the stomach was assumed to be empty and the barium was mixed either with the food or taken with a little water during the eating of solid food. The amount of barium administered was generally one ounce. The stomach was roentgenoscoped at frequent intervals and films were taken to check the roentgenoscopic observation. With the small amount of barium given the emptying time of the stomach could be determined easily and they found that one ounce of barium was quite sufficient for good vision. They found from their observations that there was in general a distinctly longer emptying rate than the tables of "digestibility" based on tube experiments. They suggest than the possible criticism in this respect might be due to the fact that the barium holds up the stomach emptying time by virtue of its weight. But in refuting this criticism they give the explanation that the difference in their results as compared with the Rehfuss tube method might perhaps be explained on the ground that the Rehfuss tube in the stomach acts as an irritant and causes exaggerated peristalsis. One striking observation which they made in their experiments was that the stomach emptying time does not appear to depend so much upon the quantity of food taken as upon the kind of food that is included and from their experiments they found that an ordinary meal leaves the stomach in three and a half to four and a half hours.

Another interesting observation which they made was the relation of hunger to stomach content. They noticed that when the meal of four ounces of potato was taken in the evening in place of dinner, in certain of the subjects when the hunger pain was most pronounced a roentgenoscopic observation revealed a small amount of food still remaining in the stomach. Thus hunger, as found in their experiments, does not necessarily result from an empty stomach and sensations of hunger which are generally supposed to be due to vigorous peristaltic contractions of the stomach were not observed. Actually toward the end of an experiment when the stomach contained only a residual ounce or two there was little evidence of peristalsis at all, though there was definite hunger. The food residuum appeared to lie inert in the pyloric antrum, and only occasionally was a trickle seen to enter the duodenum.

This same observation has been made previously on patients who were suffering from duodenal ulcer, namely, that at the moment when the hunger pain was most pronounced there still remained a small amount of residual food in the pyloric end of the stomach and the peristaltic waves were very feeble.[3,4]

From their experiments, Maile and Scott concluded that the ordinary meal leaves the stomach in about four hours, that a meal which contains much butter or cream is retained in the stomach for a much longer period, that cooking shortens the time of stomach digestion of some foods and increases it for others, and that the

[2] Maile, W. C. D., and Scott, K. J. L. "Digestibility" of common foodstuffs as determined by radiography. *Lancet*, Jan. 5, 1935, *1*, 21–23.

[3] McClure, C. W., Reynolds, L., and Schwartz, C. O. On the behavior of the pyloric sphincter in normal man. *Arch. Int. Med.*, 1920, *26*, 410–423.

[4] Reynolds, L., and McClure, C. W. Motor phenomena occurring in normal stomachs in the presence of peptic ulcer and its pain observed fluoroscopically. *Arch. Int. Med.*, 1922, *29*, 1–11.

length of stomach digestion of different foods cannot be taken as a measure of their digestibility.

While a great deal is known about the emptying time of the stomach for the various foodstuffs, there seems to be a considerable lack of general knowledge of this fact and the work of Maile and Scott on the digestibility of common foodstuffs as determined in normal individuals should be a stimulus to further study, with particular attention to the small intestine, for here we think lies the explanation for many of our as yet unknown normal physiological phenomena. Since the small intestine is somewhat inaccessible to tubing a great deal of information might be obtained by its roentgenologic study.

OSCAR LAERTIUS NORSWORTHY
1871-1935

DR. NORSWORTHY was born on February 26, 1871, at Jasper, Texas, the son of Laertius and Sallie B. (Ryall) Norsworthy, the former a native of Louisiana and a life-long agriculturist in Texas, and the latter a member of a well-known pioneer Texas family. Until he was sixteen years of age Dr. Norsworthy resided on the home farm, attended public school and worked intermittently in a saw mill, following which he attended high school at Jasper.

He then went to the Agricultural and Mechanical College, and in 1893 he graduated from the medical department of Tulane University with the degree of Doctor

of Medicine. To further prepare himself for his chosen profession he served as an intern and ambulance surgeon at the Charity Hospital in New Orleans, Louisiana. In 1895 he located in Houston, Texas, where he was engaged in general practice until 1909. In that year he established The Norsworthy Hospital, a private hospital where he was Surgeon in Charge until 1919, after which time he began to limit himself exclusively to radium treatment. In 1921 he gave the hospital and grounds to the Methodist Conference. It is now known as The Methodist Hospital of Houston.

He specialized, as noted, in radium therapy in neoplasms, and was an acknowledged authority on these subjects. His attendance at most of the important clinics and radium centers both at home and abroad further fitted him for his chosen specialty.

In 1928, Dr. Norsworthy moved to San Antonio, where he continued his work as part owner and member of the staff of the Medical and Surgical Hospital where he had his offices. He was a member of the Texas State Medical Society, American Medical Association, the American Radium Society, a Fellow of the American College of Surgeons, and at times held important offices in several of these organizations.

On November 30, 1910, Dr. Norsworthy was united in marriage to Sarah Sanford Gibbs, daughter of Sanford Gibbs of Huntsville, Texas, a pioneer family of that city. Mrs. Norsworthy died in November, 1933.

On December 29, 1934, he was united in marriage to Mrs. Carrol of San Antonio, Texas, a boyhood and school days friend. It was while on a trip to California one week later that he died suddenly of coronary occlusion (January 5, 1935). His body was interred in the old family cemetery at Jasper, Texas, where he was born and reared.

A. G. Cowles

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Atlantic City, N. J., Sept. 24–27, 1935.

American College of Radiology
Secretary, Dr. B. H. Orndoff, 2561 N. Clark Street, Chicago, Ill. Annual meeting: Atlantic City, N.J., 1935.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Atlantic City, N.J., June 10–14, 1935.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting, 1935, to be announced.

Radiological Section, Baltimore Medical Society
Secretary, Dr. W. B. Firor, 1100 N. Charles St., Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Los Angeles County Medical Society
Secretary, E. N. Liljedahl, Los Angeles, Calif. Meets on the fourth Wednesday of each month at the California Hospital.

Radiological Section, Southern Medical Association
Secretary, Dr. H. J. Walton, 104 W. Madison St., Baltimore, Md. Annual meeting, St. Louis, Mo., Nov. 19–22, 1935.

Brooklyn Roentgen Ray Society
Secretary, Dr. A. L. Voltz, 115 Myrtle Ave., Richmond Hill, N.Y. Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N.Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, General Hospital, Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. Otto Glasser, Cleveland Clinic. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida Radiological Society
Secretary, Dr. F. J. Payton, Miami Beach, Florida. Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr. H. W. Grote, 219 N. Main St., Bloomington, Ill. Regular meetings held quarterly.

Indiana Roentgen Society
Secretary, Dr. J. N. Collins, Indianapolis, Ind. Annual meeting each February 22 in Indianapolis.

Michigan Association of Roentgenologists
Secretary, Dr. S. W. Donaldson, St. Joseph's Mercy Hospital, Ann Arbor, Mich. Three meetings a year, Fall, Winter, and Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting designed by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

New England Roentgen Ray Society
Secretary, Dr. Thomas R. Healy, 370 Marlboro St., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

New York Roentgen Society
Secretary, Dr. E. F. Merrill, 30 W. 59th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. F. C. Rulison, Medical Arts Bldg., Syracuse, N.Y. Three meetings a year—January, May, and November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, Williamsport, Pa. Annual meeting, Schenley Hotel, Pittsburgh, Pa., May 17–18, 1935.

Philadelphia Roentgen Ray Society
Secretary, Dr. Thomas Loughery, Germantown Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N.Y.
Secretary, Dr. W. W. Fray, Strong Memorial Hospital. Meets monthly on second Thursday from October to May, inclusive, at 7:45 at the Rochester Medical Association Building.

St. Louis Roentgen Ray Society
Secretary, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

South Carolina X-Ray Society
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston. Meets at time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary-Treasurer, Dr. J. H. Smith, Lubbock, Texas.
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Department of Roentgenology Staff Meeting
Secretary, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich.
Meets each Monday evening from September to June, at 7 p.m. at University Hospital.

University of Wisconsin Roentgen Club
Secretary, Dr. E. A. Pohle, 1300 University Ave , Madison, Wis.
Meets monthly on last Thursday, October to April, Service Memorial Institute, at 4:30 p.m.

Virginia Roentgen Ray Club
Secretary, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 p.m., at 32 Welbeck St., London, W. 1, or as advertised.

Electro-Therapeutic Section of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:30 p.m. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

Section on Radiology, Canadian Medical Association
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale.
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, II.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
Secretary, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Nicolae Busila, 44 Elizabeta Blvd., Bucarest.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6.30 p.m. at Zentral-Röntgen Institut des allgemeinen Krankenhauses, Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto, Japan. Meets bi-monthly on third Sunday.

PAN AMERICAN MEDICAL ASSOCIATION'S CRUISE FOR 1935

The S.S. "Columbia," the largest American cruise ship afloat—40,000 tons, with three swimming pools and a sand beach on deck—has been selected by the officials of the Pan American Medical Association for the Cruise. The ship will sail from New York on July 18, returning to New York on August 28. The itinerary will be as follows: New York, Havana, Curacao, five days at Rio de Janeiro (where a scientific congress will be held), three days at Santos (for attending a scientific convention at Sao Paulo), Trinidad, Santo Domingo, Kingston (Jamaica), Havana, and New York.

Accommodations per person are from $450.00 up, which is as low as $11.00 a day.

This will be an unusual opportunity to combine a wonderful vacation with recreation, education, good fellowship, and good health.

The Section on Radiology is one of the live members of the Association. Its President is Dr. Frederick W. O'Brien, 465 Beacon Street, Boston, Mass., who invites you to contribute some article on Radiology. Please say that you will go, and send in your title within thirty days, if possible.

For further particulars of the Cruise, write to the Director-General, Dr. Joseph J. Eller, 745 Fifth Avenue, New York City.

ALBERT SOILAND
Chairman Executive Committee
Section on Radiology

DAVID ANDERSON-BERRY GOLD MEDAL

A David Anderson-Berry Gold Medal, together with a sum of money amounting to about £100, will be awarded in July, 1935, by the Royal Society of Edinburgh to the person who, in the opinion of the Council, has recently produced the best work on the nature of roentgen rays in their therapeutic effect on human diseases. A similar award will be made every three years.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

X-Rays in Theory and Experiment. By Arthur H. Compton, Ph.D., Sc.D., LL.D., Nobel Laureate, 1927, Charles H. Swift Distinguished Service Professor of Physics, University of Chicago, and Samuel K. Allison, Ph.D., Associate Professor of Physics, University of Chicago. Second edition of X-Rays and Electrons, by Arthur H. Compton. Cloth. Price, $7.50. Pp. 828, with numerous illustrations. New York: D. Van Nostrand Co., Inc., 1935.

This book is a revision of Compton's "X-Rays and Electrons," first published in 1926, which is still the standard textbook of advanced x-ray physics. The present edition is slightly more than twice the size of the previous one, and the additional pages have been well filled with the essence of the modern developments.

In the preface Compton explains that the long delay in the appearance of this book, from 1928 when his last revision was published, was due to his inability to write a new book and keep pace with the rapid developments since that time. He sketches some of these developments briefly. He gives credit for the greater part of the present work to his co-author, Allison, who wrote the chapters on crystal structure, dispersion and absorption of x-rays and x-ray spectra. Compton himself wrote the chapters on the scattering of x-rays and the introductory chapter.

The book of course starts off with a brief history of the discovery of the x-ray and immediately goes on to a very general consideration of the production of the ray and its absorption by solid materials and gasses. The roentgenologist with little or no mathematical interest will find here a clear and complete discussion of absorption and the absorption coefficient. The reader will at once find for himself the shortcomings, in part at least, of the classical theories and the empirical formulae. Long derivations, required of students and for the most part cordially hated by roentgenologists, are carefully avoided, and in a subsequent chapter the reader is led into the more modern concepts of scattering and absorption so absolutely essential to practical considerations of modern "super-voltage" therapy. Here the roentgenologist will find the formulae of Klein-Nishina and Breit-Dirac presented, along with the experimental proof of these theories by Lauritsen and Chao, prefaced by plenty of experimental and theoretical work to make them understandable. Here also the roentgenologist with an interest in modern physics will find the classical wave theory brought into accord with the modern quantum theory. The chapter ends with a brief summary from which we quote: "Our investigation of X-ray scattering from the standpoint of the hypothesis of photons thus gives results in complete accord with experiment. Similarly, our study based on the classical wave theory has enabled us to account for the chief features of diffraction of X-rays and their polarization. We have seen how the wave mechanics brings these two conceptions into a unified whole."

In the second chapter of the book the reader will find a complete discussion of the production of roentgen rays. Here, he who would read around the formulae rather than through them will find more hurdles to jump, but he should have an interesting time of it nevertheless. Matters of everyday practical interest such as the production of the continuous spectrum and the characteristic spectra, the effect of voltage, effect of various target metals, and the difference between thin or thick metallic targets are made very clear.

In the field of therapy perhaps no subject is of as great immediate importance as the question of measurements of intensity. One whole chapter of 110 pages (Chapter VII, "The Phenomena Associated with the Ejection of Photo-Electrons by X-Rays") is devoted to the study of the ionization of gases by roentgen rays, production of secondary beta rays in a gas, absorption coefficients in gases and the measurement of relative intensities by ionization. Through this chapter the reader is given as clear an insight as possible into the workings of an ionization instrument, its requirements, limitations and its dependence upon the energy of the photon and hence the wave length. Here

to a certain extent are pointed out the most dangerous experimental errors to be guarded against.

Some chapters of the book will be of academic interest only to the practical roentgenologist, such, for instance, as the last chapter devoted to accurate methods of wave length measurement. In this chapter the double crystal spectrometer and focusing spectrographs are discussed. These instruments are of the most fundamental importance in physical research but for obvious reasons have not so far found a place in therapy.

The chapters on x-ray crystal structure and x-ray spectroscopy should prove both interesting and stimulating. These methods have long since ceased to be matters of academic interest only, and are finding the widest practical use in experimental and control work in the most coldly practical industries. The roentgenologist and pathologist have so far shown little interest in them. Compton and Allison present the underlying theories, the general experimental requirements and the basic ideas of interpretation in a very excellent manner.

The book is not intended as an experimental handbook, but rather as a general manual, as complete as possible. To quote the authors: "The main objective of X-RAYS IN THEORY AND EXPERIMENT is to present a comprehensive view of the whole field, to call attention to those aspects which seem of the most fundamental physical significance, and especially to discuss the theory of the phenomena in sufficient detail that their meaning can be appreciated."

Throughout the book the authors have tried to give references to the most significant publications covering each field of theory or experiment. In so doing they have given the reader the bibliography he needs to complete his search in any field in which he is interested without the necessity of looking up large numbers of relatively unimportant publications.

In general, as might be expected of these authors, the book is most comprehensive and presented in a masterly manner.

K. E. Corrigan

Radiothérapie: Rayons X-Radium. Par Paul Cottenot, Médecin électro-radiologiste de l'Hôpital Broussais, and Simone Laborde, Chef du Service de Curiethérapie à l'Institut du Cancer. (Traité de Pathologie Médicale et de Thérapeutique appliquée. Tome XXXII, fasc. II.) Paper. Price, 70 fr. Pp. 514, with 80 illustrations. Paris: Norbert Maloine, 1934.

This book, by two celebrated French radiologists, is divided into four parts. In the first there is a discussion of the physical properties of roentgen rays, the apparatus by which they are generated, and a general outline of the scheme of treatment. In the second part the radioactive substances are similarly dealt with. In the third part the action of radiation on normal and pathological tissues is given in some detail. The fourth part takes up the actual treatment of diseases of the skin, diseases of the blood-forming system, the vascular diseases, those of the bone and joints, the nervous system, the affections of the respiratory, digestive, and genitourinary tracts, inflammations, and finally cancer of the various organs. In this exposition the indications, contraindications, methods of application of radiation and likely complications are discussed in a very practical manner. In the last chapter there is a consideration of the protective devices which have been recommended in radiotherapy.

Since throughout this book the practicability of the various methods is emphasized, it has much interest for the specialist who may compare the authors' techniques with his own, for the student, who may orient himself by the experience of the authors, and for the clinician who may from the material (aside from its technical side) obtain up to date information on what is to be expected from correctly given radium and roentgen therapy.

E. T. Leddy

The Clinical Aspects of Visceral Neurology: With Special Reference to the Surgery of the Sympathetic Nervous System. By W. K. Livingston, M.D., Clinical Associate in Surgery, University of Oregon Medical School. Cloth. Price, $5.00. Pp. 254, with 46 illustrations. Springfield, Illinois, and Baltimore, Maryland: Charles C Thomas, 1935.

This monograph represents the first attempt in this country to get into book form our knowledge of visceral neurology as applied to clinical conditions. It should be of great interest not only to all those interested in disorders of the autonomic nervous apparatus, but also to those interested in elucidating the problem of visceral pain.

The advances made in this field in the last ten years have been so rapid that only a fragment of the profession have become acquainted with the facts already learned and only a few have applied this physiological knowledge to the treatment of disease entities as seen in man. Livingston was among the early workers in this country to become interested in this matter and his considerable clinical experience, as well as his natural bent of a physiological nature, has now given him the opportunity to treat systematically this field of medical work.

The book is arranged in an orderly sequence, beginning with a review of the essential anatomy, physiology and pharmacology, clearly demonstrating the nervous pathways to and from our internal viscera and their possible functions. There then follows a discussion of clinical disorders in which the visceral nerves are involved and for which surgical intervention upon these nerves might be of benefit. These disorders are largely those dealing with the vascular apparatus, certain hollow viscera, as well as certain peripheral diseases such as chronic arthritis where perhaps the circulation is again the disabling factor. Then follows a careful, though rather brief, description of the methods used in studying the action and state of the involuntary nervous system. It is perhaps a little unfortunate that these tests are not elaborated in more detail, since the crux of this whole matter depends upon whether we can secure measurable evidences of a disordered function in the involuntary apparatus. Moreover, it is only by such measurable tests that we can point out the beneficial or deleterious results of surgical operations. The final discussions of surgical rationale and surgical technique point out the major procedures now advised in certain clinical conditions.

As a whole, the monograph would appear to cover a wider field and to be of a great deal more use to workers in this field than the recent English publication by Gask and Ross entitled "The Surgery of the Sympathetic Nervous System." Livingston's book, in particular, is an admirable treatise on visceral pain and, in the reviewer's opinion, a better treatise than has heretofore been presented. Its appearance is most timely since the surgery of the sympathetic nervous system needs standardization lest too enthusiastic individuals attempt procedures without preceding their surgery by tests which give some promise that the operation will be beneficial.

Elliott C. Cutler

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., M. S., 105 Rutledge Ave., Charleston, S. C.

SIMULTANEOUS STEREOSCOPIC STUDY OF THE NASAL ACCESSORY SINUSES

By FRANK HUBER, M.D.
NEW YORK CITY

BY employing the combination head rest recently described[1] and a suitable metal mask, stereoscopic views of the nasal accessory sinuses in four different projections on two 10″×12″ films may be obtained.

The technique again embraces the principle of adjusting the head rest for the different positions of the patient's head without changing the angle of the tube from the vertical. The metal mask has two apertures which are used successively. Four views, lateral, nose-chin, nose-forehead and vertico-mental, are projected on each cassette in the order named. The central ray of the vertical roentgen beam is made to pass through the center of one aperture. With this set-up, stereoscopic views (transverse shift) are taken with the head in the lateral position. The head is then postured for the nose-chin view, the cassettes rotated and stereoscopic views

[1] Herendeen, R. E., and Huber, F. A combined sinus and mastoid head rest. Am. J. Roentgenol. & Rad. Therapy, 1933, *30*, 817–820.

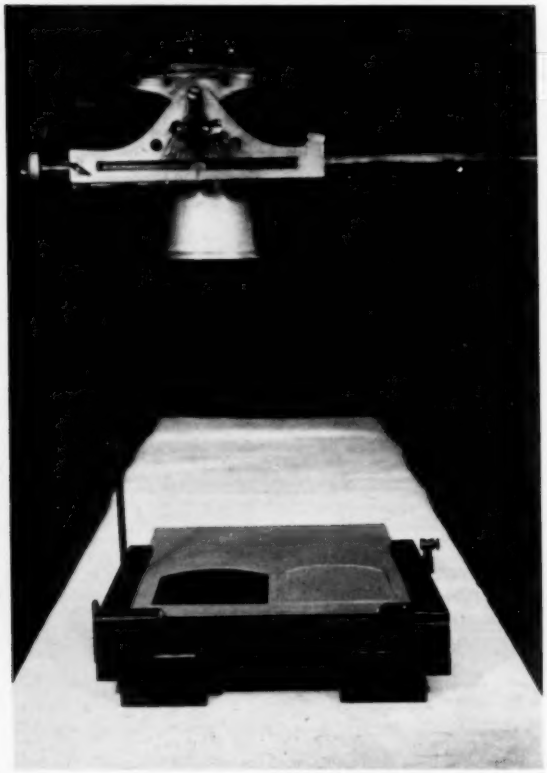

Fig. 1. Front view of head rest with tube centered over first aperture for lateral and nose-chin positions.

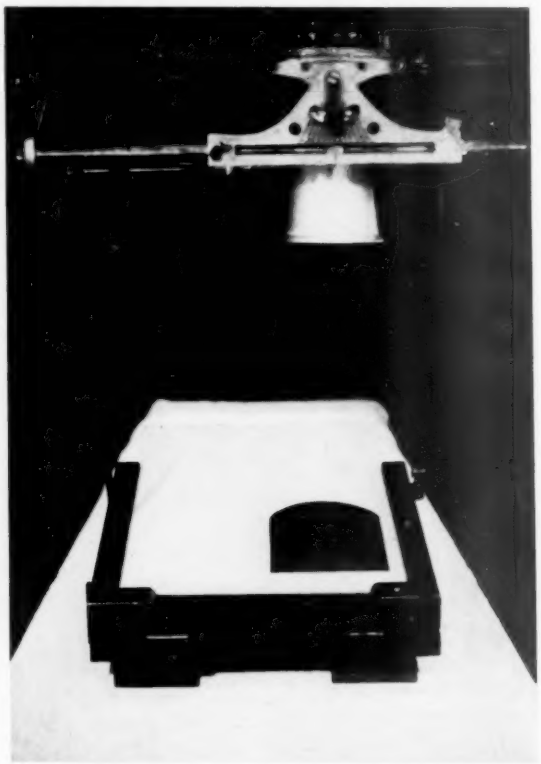

Fig. 2. Front view of head rest with tube centered over second aperture for nose-forehead and vertico-mental positions. Note tilted tunnel.

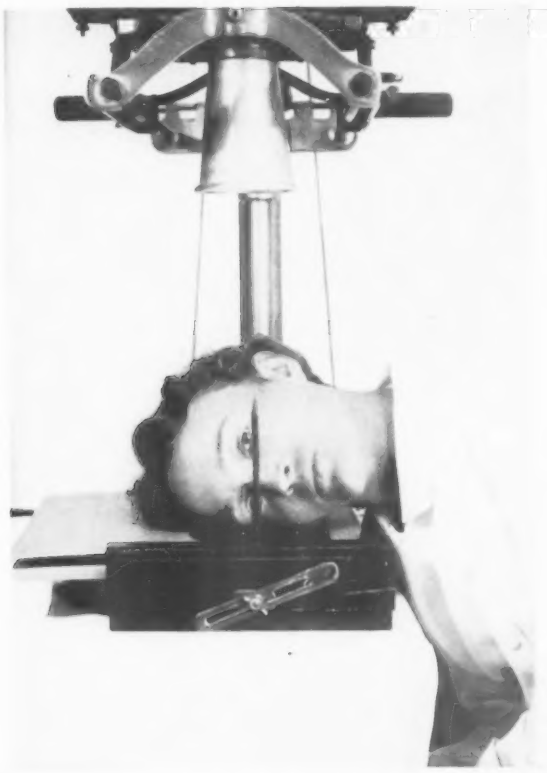

Fig. 3. Set-up for lateral position.

Fig. 4. Set-up for nose-chin position.

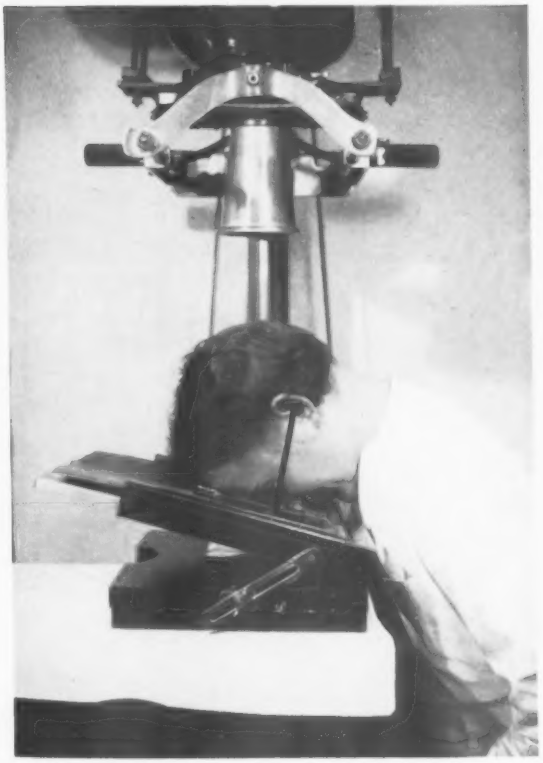

Fig. 5. Set-up for nose-forehead position.

Fig. 6. Set-up for vertico-mental position.

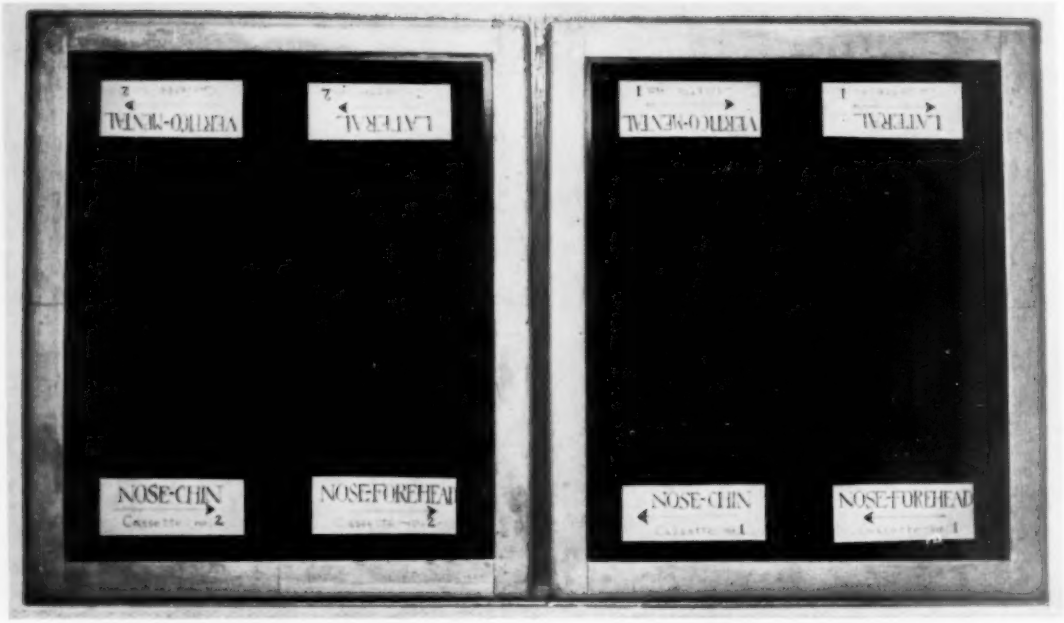

Fig. 7. Illustrating marking of cassettes. Note that position and direction of stereo shift is indicated for each quadrant.

made. Then the tunnel is tilted, and the central ray is made to pass through the center of the second aperture. With this set-up, stereoscopic projections in the nose-forehead position and, after rotating the cassettes, in the vertico-mental position are made.

Fig. 8. One of final stereoscopic set.

The only change in position of the roentgen tube is from the center of one aperture to the other and, of course, its excursion through the extent of the stereo shift for each position.

To obtain films on which all four views stereo simultaneously necessitates rotation of the cassettes in synchrony with the direction of the stereo shift. This result is produced by marking the four quadrants of each cassette front. Subsequent maneuvers are then automatically regulated.

The stereo shift is transverse so that the sagittal plane of the stereoscopic image is vertical. Instead of the full stereoscopic shift in which none of the projections are made in the exact median sagittal plane, a half distance shift may be employed with the central ray coincident with the median plane for all four projections on one of the films.

On the final films, two views, the lateral and vertico-mental, appear inverted. One soon learns to discount this apparent objection, but if this obstacle to interpreta-

tion be insurmountable, each film may be suitably cut and the inverted halves reversed.

This principle can of course be adapted to the Potter-Bucky diaphragm. It is felt, however, that though it is possible to obtain satisfactory soft tissue shadows with the Potter-Bucky diaphragm, the usual product, rich in contrast, lacks information as to the soft tissue changes which comprise the greater part of sinus pathology. It must also be borne in mind that eight exposures using Potter-Bucky diaphragm technique, approach an epilating dose for a single area, to say nothing of the possibility of retakes or re-examination. Without the diaphragm, the exposure is cut down to one-third or one-quarter of this amount. Retakes are made separately on 8″×10″ cassettes as needed, although the whole procedure may safely be repeated.

Any simple method of identifying and marking the films is adequate.

This method simplifies rather than complicates the routine of examination. The economy of time, apparatus and films and the condensation of technique, are distinctly worth while.

The greatest advantage of the procedure is the opportunity to study, simultaneously, stereoscopic projections of the four positions necessary to accessory sinus roentgenology.

SMALL RADIUM ELEMENT CELLS

A MORE FLEXIBLE FORM FOR PRACTICAL APPLICATION*

By HYMAN STRAUSS, M.D.
BROOKLYN, NEW YORK

PERSONAL experience extending over a period of about two years with the use of small radium element cells in approximately 200 cases has shown them to be of decided advantage. This and the absence of any published report on the use of this type of cell in the American literature prompted the presentation of this paper.

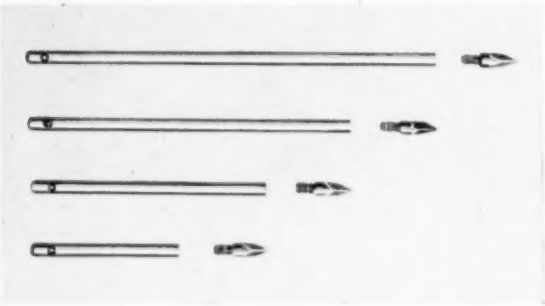

FIG. 1. Sheath needles to hold radium cells. Different lengths to accommodate one to four cells.

The removable radium element cell is a small platinum tube without eyelet whose length is 11.5 mm.; external diameter 1.0 mm.; and the thickness of its wall 0.2 mm. platinum. It is a little larger than a radon seed. Varying amounts from 1 to 5 mg. of radium sulphate can be made up to fit this same sized cell. These cells are of such strength that they lend themselves most easily to the French method of calculation on the basis of millicuries-destroyed. If cells of 1.33 mg. (or multiples thereof) are used, dosage can be very easily calculated on the basis of millicuries-destroyed. If cells of 1.33 mg. are used 10 microcuries are destroyed per hour, etc. This multiplied by the number of cells and also by the number of hours applied gives the total number of millicures-destroyed. If cells of 3.33 mg. are used 25 microcuries are destroyed per hour. If one prefers to use milligram-hours as the method of dosage computation—these cells are of even greater use—three cells (3.333 mg.) equal 10 mg. and fifteen cells equal 50 mg., so one can readily determine the dosage delivered to the lesion in toto or any portion thereof.

The small removable element cell is a unit of maximum adaptability. The radium is contained in a cell that can be inserted in applicators of various types, sizes, shapes and filtrations. It can therefore be used in all types of cases requiring radium as contrasted with the fixed radium needles where only a particular kind is suitable in each case. These cells can be used to build up applicators of varying amounts of radium, be they sheath needles with removable points or eyes, capsules or flat applicators of any description. The specialist in his own field may easily devise any number of flat applicators or plaques of various sizes, shapes, screens and strengths. These he can construct by using any number of increments of these small removable radium cells, just as a child erects a structure with blocks. The same procedure can be followed with sheath needles. One can use any number of cells as, for example, one small needle containing

a *b*

FIG. 2. *a*. Sheath needle. *b*. Radium cell.

one cell (of the Treves type) which can be used on a very small lesion on the lip, or long needles holding four cells end on end which are adequate for usage in the largest breast tumor.

The capsules or tandems with which I am most familiar lend themselves to the possible employment of any number of special applicators. Because of their small

* Read at the Nineteenth Annual Meeting, American Radium Society, Cleveland, Ohio, June 11–12, 1934.

size the cells can be used in intrauterine capsules designed to bend in any direction. The length of these capsules can be increased or decreased by the addition or removal of one or more segments. They can be used in the Clark or the Healy type of cervical applicator, which, on the other hand, is impossible with fixed radium needles. To date, I have met with no type of gynecologic technique which I or any of my numerous gynecological colleagues have been unable to employ with this new removable cell. Radium in this form should never be idle because of its extreme flexibility and adaptability to almost every radium need. The only limitation that I can see is the lack of ingenuity of the radiologist using it.

However, one must admit that these small cells must be handled carefully or they will be crushed, bent or lost. It must be remembered that there are special instruments and applicators for these cells. One cannot deny that a great deal of handling will be necessary if one continually changes from one applicator or another. To reduce the handling to a minimum I have found it simplest to leave the applicator intact until I have a patient whose treatment will require another applicator. Additional protective facilities are used to compensate for any increased handling.

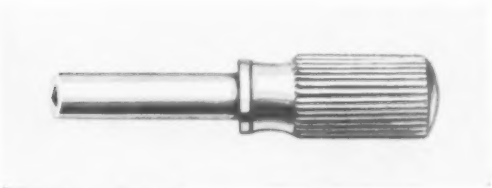

Fig. 3. Tool for unscrewing points.

I believe that this cell is the nearest approximation to radon in flexibility that can be obtained in any fixed unit.

In conclusion, I believe that a small quantity of radium in this form will accomplish the same as a far greater quantity distributed in a group of fixed strength containers.

Acknowledgment is herewith made to Dr. William E. Howes for his cooperation in this work.

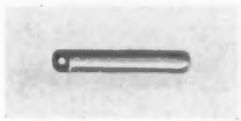

Fig. 4. Tube for holding three cells.

Fig. 5. Flat applicator for a number of cells.

DISCUSSION

Dr. George E. Pfahler, Philadelphia. Referring to the paper of Dr. Strauss, which I think is excellent, I would like to ask him in what respect this differs from the general equipment and preparations which Dr. Schley of Brussels has been using for many years, and has described. He showed it to me in 1930 when I visited him. I think it excellent for it gives more flexibility. The objection is that it involves some risk in shifting these applicators, but this is no greater than others. If properly handled it can be done.

Dr. Strauss (closing). Regarding Dr. Schley I have not come across his work in the literature. This removable radium element cell is prepared by the Radium Chemical Company of New York City.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Egas Moniz. L'angiografia cerebrale. (Roentgenography of the vessels of the brain.) *Arch. di radiol.*, 1933, *9*, 629–642.

The author describes his method of roentgen demonstration of the vessels of the brain. He now uses thorotrast instead of the sodium iodide that he used at first. He injects 16 c.c. of 25 per cent thorotrast rapidly into the common carotid under local anesthesia. The artery is exposed near the clavicle between two bundles of the sternocleidomastoid. When 12 c.c. of the fluid has been injected an instantaneous roentgenogram is taken with an exposure time of one-tenth of a second. This shows the arteries. The remainder of the 16 c.c. is injected and another roentgenogram taken which shows the veins.

Tumors of the brain can be diagnosed by this method because of the displacement of the vessels brought about by the pressure of the tumor. A number of illustrative roentgenograms are given. This method does not replace ventriculography; the two supplement each other.

Arteriography shows that the velocity of the blood is greater in the brain than it is in the other tissues of the head. The method promises to be valuable not only in the diagnosis of brain tumors but in the study of the circulation of the brain and head.—*Audrey G. Morgan.*

Jacobovici, J., and Jianu, S. La radiographie des voies salivaires après injection de substance opaque (sialographie). (Roentgenography of the salivary ducts after injection of opaque substance; sialography.) *J. de radiol. et d'électrol.*, Sept., 1933, *17*, 507–510.

The first results on sialography were reported by one of the authors (Jacobovici) before the Society of Medical Sciences of the University of Cluj in January, 1926. Since that time the method has been employed routinely with very satisfactory results. The technique of procedure is as follows: The injecting needle is introduced into the excretory canals of the various salivary glands. If the orifices are not immediately detected a gentle massage is applied until saliva is secured showing the site of the orifice. For the Warton canal the needle is inserted through the external orifice in such a manner that it points obliquely downward and outward, the needle being introduced for a distance of 1 or 2 mm. For the injection of Stenon's duct, the authors proceed as follows: They grasp with the left hand the right cheek of the patient and with the right hand the left cheek. One of the fingers is on the external wall and the other on the internal wall. Then the cheek is drawn forward and everted as much as possible. In this way, the external orifice of Stenon's canal is approached and the angulation of the canal at the level of the buccinator and even the masseter is corrected. The needle is inserted obliquely outward traversing several millimeters underneath the mucosa. One must be very careful here not to produce false routes, in which case the injected substance will infiltrate the wall of the cheek. It is advisable to first introduce a very thin sound to explore the direction of the duct. Neo-iodipin Merck, 20 to 40 per cent, is used for the purpose of injection. The quantity amounts to 2.5 c.c. to 4 c.c. for the submaxillary gland, whereas if the excretory canal alone is injected 1 to 1.5 c.c. suffices. After the injection of 2.5 c.c. the gland swells and after 4 c.c. the tumefaction appears as a hard resistance on palpation. A quantity of 4 to 6 c.c. is injected for the parotid gland. To prevent the reflux of the opaque substance through the external orifice, a small tampon is applied, which is removed at the time of taking the roentgenograms. A posteroanterior and lateral incidence of the beam is used for the parotid, the former permitting, in addition to the visualization of the gland proper, the demonstration of Stenon's duct with its two ramifications, whereas the latter shows the entire tract of the canal. For the visualization of the submaxillary glands the same incidences are used except that here the lateral incidence is directed in the same manner as practiced for the roentgen examination of the lower jaw.

The interpretation of the roentgenograms is rather simple. The obstructions at various levels of the excretory canals are easily detected. It

is also possible to make a differentiation, especially at advanced age, between a salivary calculus which does not show in the ordinary roentgenogram, and an obstruction due to tumor. It is further possible to show in case of tumor of the parotid gland the extent of the invasion and the amount of destruction of the normal gland.

As a whole, the conclusion is reached that sialography forms a very valuable method of investigation in the diagnosis of lesions of the salivary glands and their ducts.—*T. Leucutia.*

NECK AND CHEST

Doctor, Remus I., and Radu, Ion. Papilomul laringean. (Laryngeal papilloma.) *Cluj. med.*, May, 1933, *14*, 299–304.

Laryngeal papilloma is a tumor having a granular muriform surface, or occasionally forming a cauliflower-like proliferation of a pale rose color. It involves chiefly the vocal cords but may extend to the entire larynx or even as far down as the trachea and pharynx. Although histologically it is essentially benign, through its localization it often proves of great clinical malignancy leading not infrequently to death. It occurs more frequently in children where the prognosis is also more severe. The symptomatology consists first in disorders of phonation and later in respiratory disorders. In a certain number of cases rapid extension of the papilloma leads to glottis spasm, secondary edema and complete obstruction of the air space.

The authors were able to observe 14 cases of laryngeal papilloma, 7 of which occurred between the ages of seventeen and thirty-eight, and the other 7 between the ages of two and seven. Of the children one arrived too late for tracheotomy so that he died from asphyxiation, in 3 a tracheotomy was performed, in 2 of which this remained permanent, and the other 3 have escaped tracheotomy, the treatment leading either to amelioration or cure. Of the adults, 3 have remained cured following a single surgical intervention, 2 were cured following repeated interventions and application of roentgen rays, one is still under treatment with multiple recurrences, roentgen therapy proving likewise inefficient, and the last proved to be at later examination a tuberculous lesion. In reviewing all methods of treatment, such as the chemical (salicylic acid, chromic acid, nitric acid, etc.), surgical (excision) and roentgen therapeutic, no definite conclusions can be drawn as to the relative value of each of the methods. It was observed that sometimes the lesion healed spontaneously, at other times following a simple tracheotomy and the single excision of the papilloma and again at other times following the application of chemical agents or roentgen rays and radium or a combination of several of them. A certain percentage will resist all sorts of treatment and finally will terminate fatally. The authors are not as optimistic concerning the final favorable prognosis as other investigators. —*T. Leucutia.*

Baumann, Theophil, and Gander, G. Interessanter Röntgenbefund bei typischer Ösophagusatresie. (Roentgen findings in an interesting case of typical atresia of the esophagus.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 214–217.

This is a report of a case of esophageal atresia occurring with a tracheo-esophageal fistula. An opaque meal permitted a detailed study of the deformity, the findings of which were confirmed post mortem.—*E. T. Leddy.*

Schilling, Carl. Die Anwendung der Flächenkymographie in der Diagnostik der Herzerkrankungen. (The use of surface kymography in the diagnosis of heart disease.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 241–253.

Surface kymography is better than screening or roentgenography for bringing out the relationships and movements of the various portions of the heart. It gives a purely objective presentation of the contractions of the chambers dissociated from one another. An analysis of the various types and amplitude of movement may lead to important differential diagnostic conclusions about the status of the heart and great vessels. The author illustrates 10 selected cases by roentgenograms, surface kymograms and cinematograms and discusses differential points as presented by each method. The findings were all confirmed by operation or autopsy. The method does not replace cinematography but is rather a way of providing a series of consecutive images instead of a simple observation of movement which is obtained by subjective roentgen cinematography.—*E. T. Leddy.*

Lenk, Robert. Das "Mediastinalschnellen," ein funktionelles Symptom bei Bronchostenosen geringen Grades. (The "rapid mediastinum," a functional symptom of mild bronchostenosis.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, Jan., 1933, *47*, 90–94.

Bronchostenosis of mild degree can be recognized by observing the movements of the mediastinum by having the patient take short forced breaths through the mouth or nose.—*E. T. Leddy.*

Sylla, Adolf. Über die Lungenzeichnung im Röntgenbild mit besonderer Berücksichtigung entzündlicher Erkrankungen. (The roentgenologic markings of the lungs with special reference to inflammatory diseases.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 159–174.

Lung markings in the normal roentgenogram are due to the vessels; only after disease processes can the bronchi, nodes and lymph vessels be visualized. The branches of the pulmonary artery form a network the size of the meshes of which are varied according to the lesions in the lung. The diagnostic characteristics of these networks are illustrated by roentgenograms.—*E. T. Leddy.*

Lanza, A. J., and Vane, Robert J. The prevalence of silicosis in the general population and its effects upon the incidence of tuberculosis. *Am. Rev. Tuberc.*, Jan., 1934, *29*, 8-16.

The authors' rough, but obviously conservative, estimate is that over 500,000 workers are exposed to silica dust in harmful degree in the United States. This figure justifies the assumption that a large number of industrial workers are the victims of silicosis and that these silicotics contribute to the high incidence of tuberculosis and the high death rate from this disease in industrial workers, particularly in later years. A comparison of the mortality rates from tuberculosis occurring among men engaged in occupations with exposure to silica dust with the mortality expectancy prevailing among standard lives at the same age levels shows 60 deaths from tuberculosis against 6 expected. The extent of family infection due to silicosis plus tuberculosis is uncertain, but under certain conditions, at least, it may be a serious problem. Cummins of the Saranac Laboratory is quoted on a study made of a number of families of individuals with silicosis plus tuberculosis, the diagnosis being made by the roentgen ray. Over 50 per cent of the children under sixteen, living in contact with a silicotic having a positive sputum, showed roentgen evidence of tuberculous infection. Less than 30 per cent of the children under sixteen, living in contact with a silicotic having a negative sputum, showed roentgen-ray evidence of tuberculosis.—*W. R. Brooksher.*

Gardner, Leroy U. Silicosis and its relationship to tuberculosis. *Am. Rev. Tuberc.*, Jan., 1934, *29*, 1–7.

Silicosis, specifically predisposing to tuberculous infection, is being emphasized economically by numerous legal actions and the medical profession must familiarize itself with its many phases. The diagnosis is established by a history of exposure to the inhalation of silica dust in occupation, by chest roentgenograms, and to a lesser extent, by the physical examination. Roentgen diagnosis requires good films, expert knowledge and experience. The pathogenesis is fully discussed by the author and the roentgen findings in various phases are described. Seventy-five per cent of those individuals who develop silicosis die of tuberculosis, which may make its appearance at any stage of the disease, more frequently, however, in the more advanced stages of silicosis. Animal experimentation has demonstrated that partially healed primary foci of tuberculosis may be reactivated and rendered progressive by the inhalation of silica. Similarly, serial roentenograms of individuals exposed to silica have demonstrated reactivation of latent apical tuberculosis. It is probable that if either lesion contains living tubercle bacilli the dust will ultimately cause the lesions to progress. The characteristic lesion of silicosis is modified by the presence of an active tuberculous focus in the lung and possibly even inactive infections also exert a modifying effect. The theoretical and practical questions applicable to the relationship between silicosis and tuberculosis are discussed. Further study is necessary to determine if the factors of immunity and dosage, known in part, at least, in connection with simple tuberculosis, may be applied to the new condition—a combination of silicosis and tuberculosis.—*W. R. Brooksher.*

Cummins, S. Lyle. Silicosis in gold-miners and coal-miners. *Am. Rev. Tuberc.*, Jan., 1934, *29*, 17–35.

The clinical and pathological concepts of sil-

icosis are well understood, but the essential problems of etiology are not so well established. Three fundamental questions remain to be solved by investigators: (1) Is "silicosis" caused by free silica only or by some other mineral associated with the free silica in the dust of hard stone? (2) Is "silicosis" the result of mechanical irritation by insoluble dust particles retained in the pulmonary and adenoid tissues or is it caused by the solution of fine dust particles and the physicochemical action of the resulting sol or gel? (3) Is the pulmonary tuberculosis so frequently associated with "silicosis" to be attributed chiefly to the activation of preëxisting tuberculous lesions by silica and its products or rather to the effects of lymph stasis and fibrosis in favoring superinfections?

Jones' theory that fibrous minerals are of far greater importance as an etiological factor than is quartz in the production of the condition is quoted. The author favors the "solution" theory against the mechanical irritation one. For the third question the author is inclined to attribute the high tuberculosis mortality in the late middle-age period in workers exposed to silica dust to the accumulation of inhaled tubercle bacilli in the fibrotic lung rather than to a direct adjuvant action of dissolved silica. Whether by direct or indirect action, however, the inhalation of silicious dust favors the progress of tuberculosis as a terminal complication of pneumonoconiosis. The concept that the coal miner has no greater liability to death from recognized 'phthisis' than the standard group of all "occupied and retired males" is discussed on the theory that he "seems to escape" because the coal dust so modifies and detoxicates the phthisical lung lesions that the condition, though present, escapes recognition, and is therefore absent from death reports. The adsorption qualities of coal dust for toxic substances, including some of the constituents of the tubercle bacilli, is suggested as a possible detoxifying agent on the foci which may arise in the silicotic lung from time to time. The only outstanding difference between the lungs of the coal miner and the metalliferous miner when affected by silicosis is the vast store of finely divided coal dust which is concentrated under the pleura, especially about the apices, in the lymph nodes and lymph channels and in the mediastinum. In both groups there is a long drawn-out phase of "pneumonoconiosis consistent with health" which slowly gives place to a dyspnea, interfering materially with wage-earning capacity. In the metalliferous miners, this phase is markedly liable to pass on into active tuberculosis, while in the coal miner, there is but little tendency for this development although tuberculous infection is common among them.—*W. R. Brooksher.*

Riddell, A. R. The clinical aspects of simple silicosis and silicosis with tuberculosis. *Am. Rev. Tuberc.*, Jan., 1934, *29*, 36–42.

The present degree of knowledge concerning silicosis became possible with chest roentgenography. The clinical signs of simple silicosis are detailed. The roentgen findings, when considered in conjunction with a clear history of exposure, are diagnostic. The almost pathognomonic mottling observed more or less throughout the lung field is fully described. This is usually preceded by a nonspecific change, increase in the hila and an exaggeration of the normal linear shadows. It is characteristic of simple silicosis that it tends to become complicated by tuberculosis, either from reactivation of a latent tuberculous focus, which predated the development of the silicosis, or from superadded infection. The diagnosis of a complicating tuberculosis, the main problem in silicosis, is often difficult, and in many cases, serial roentgenograms are of great assistance. Shadows of tuberculous origin, however, may be masked by those of a preëxisting silicosis.—*W. R. Brooksher.*

Pancoast, Henry K., and Pendergrass, Eugene P. Roentgenological aspects of simple silicosis and silicotuberculosis. *Am. Rev. Tuberc.*, Jan., 1934, *29*, 43–60.

Tuberculosis imposed upon a silicotic process usually fails to present its characteristic clinical manifestations. The roentgen examination is the most exact means of determining the presence of pneumonoconiosis, the degree of progression and the differential diagnosis from other conditions. It is equally exact in the detection of uncomplicated pulmonary tuberculosis. To differentiate the two conditions, or to determine their coexistence is, however, not so readily accomplished. The relations of tuberculosis and silicosis are considered under nine groups of cases.

I. Cases of pulmonary tuberculosis with no roentgen-ray evidence of silicosis after several years of dusty occupation. Here differential diagnosis assumes the ability to recognize all

phases of silicosis from those of pulmonary tuberculosis. Lack of diagnostic experience is fruitful of error in this group.

II. Cases of pulmonary tuberculosis with evidences of a mild degree of silicosis after many years of service in a dusty occupation. The mild degree phase is the perivascular-peribronchial lymph node phase, a very moderate nodular or an interstitial phase. The influence of silicosis as a predisposing cause is the question for determination. In these individuals the usual appearances of adult tuberculosis are found and continue, the lesions healing with the usual fibrosis. Complete clinical and roentgenological healing would almost always imply lack of predisposition by reason of the dust. Lack of such complete healing causes doubt as to future predisposition and change in type, whether occupational change took place or not, and would require serial examinations for final determination. Due to its progressive nature, the predisposition of silicosis may manifest itself years after cessation of the dusty occupation. The authors encountered this group most frequently among coal miners, an occupation with exposure to both coal dust and a mixture of coal dust and silica. Pure coal dust, doubtless, does not produce more than a mild degree of pneumonoconiosis, but the excessive inhalation of both dusts does produce a predisposition to tuberculosis.

III. Cases of pulmonary tuberculosis with slight evidences of silicosis after very short periods of occupation in very dusty atmospheres. Here the evidences of silicosis are slight and limited to a rapid interstitial phase. The tuberculous manifestations are those of a diffuse pneumonic process with a rapid onset of marked clinical symptoms as contrasted with the characteristic comparative freedom of the more chronic cases from serious symptoms until later. A complete knowledge and understanding of the physical factors incident to the industry are absolutely essential to arrive at a correct roentgenological interpretation.

IV. Cases of advanced tuberculosis with no demonstrable evidence of silicosis after a short period of exposure to extremely hazardous atmosphere. Here the intake of silica has been unusually rapid but demonstrable changes have not developed. It must be determined if such a lung, saturated with silica and in the preliminary stage of silicosis, can act as a predisposing factor to the production of tuberculosis or can reactivate old but unhealed tuberculous lesions. Predisposition is considered a strong possibility, as yet unproved. The reactivation of old, unhealed lesions, according to animal experimentation of Gardner, can occur. The important deciding factor in this group rests upon the actual and proved physical factors in the individual's occupation and not upon the roentgen-ray findings, since the latter does not show evidences of silicosis.

V. Cases of advanced tuberculosis associated with advanced silicosis which could be a predisposing factor. Here the roentgen appearances are usually disproportionate to the clinical manifestations. These are well recognized as one of the group of silicotuberculosis with the rapidity of the progress of the infection often, if not usually, commensurate with that of the silicosis. In the slowly developing cases of silicosis, the tuberculosis runs a chronic course with symptoms of intoxication less pronounced than in non-silicotic individuals. Gardner is quoted as stating that the lymphatic obstruction of silicosis explains the freedom from toxic symptoms.

VI. Cases of advanced silicosis with coexisting tuberculosis, the differentiation of the latter condition being very difficult or impossible. Three general types of this group are recognized: (1) Where massive fibrotic consolidations of terminal silicosis must be differentiated from massive tuberculous lesions, composed of much fibrosis due to accompanying pneumonoconiosis. When peripherally located these must be considered as wholly or partly tuberculous in origin. Unilateral or older bilateral lesions of this nature will produce homolateral displacement of the trachea and the hilar shadow, which is not a finding in bilateral purely silicotic consolidations. On overexposure of these lesions to the roentgen ray there will appear a generally homogeneous shadow of the silicotic consolidation with the stringy appearance from tuberculous fibrosis, coarse and far apart, while cavities and calcifications may be noted. The purely silicotic consolidation will exhibit loose trabeculation and less homogeneity. (2) A rather extensive consolidated lesion in the upper chest, more marked on one side or unilateral, with associated nodular lesions usually lower down. This is a most difficult differentiation. (3) The presence of the tuberculous infection in an apparently purely nodular type of silicosis, usually a superimposed process. The

progress of the nodules must be serially studied for diagnosis.

VII. Cases of tuberculosis appearing many years after cessation of a dusty occupation and discovered to coexist with a late-appearing silicosis. This is a common type and one which should caution employers of labor to ascertain carefully the worker's past employment record.

VIII. Cases whose roentgenograms show very obvious calcification in the pulmonary lymph nodes, without a calcified primary nodule, where the question arises as to the possible effects of childhood tuberculosis upon the progression of the silicosis. This is considered a theoretical problem.

IX. In this group is discussed the great necessity for care as to the hygienic living and working conditions of individuals exposed to all possible harmful dusts. The responsibility of the employer is emphasized.—*W. R. Brooksher.*

Ehrenburg, G. E. A critique of atelectasis in pulmonary tuberculosis. *Am. Rev. Tuberc.*, Oct., 1933, *28*, 457–469.

"Total and sudden deflation of a large area of lung parenchyma, due to failure of inspiratory lung power, but in the absence of any signs of obstruction or compression of the air passages," the definition of massive collapse given by Pasteur of London, is considered to give a better concept of the complication than the present usual description of atelectasis as largely due to obstruction or compression of air passages, with consequent absorption of air from the alveoli. Vasomotor disturbances, spasmodic contraction of the bronchial muscles, allergic reactions and central nervous system lesions are discussed as etiologic factors. Bronchial obstruction by secretions is of rare occurrence, and when it happens, the plug is expelled sooner or later by the perfect protective defences of the respiratory tract: cough, dilatation and contraction of bronchial muscles and elastic tissue, cilia action and the porous openings of each alveolar wall which permit air from an open alveolus to enter a clogged one. Hyperfunction of the lungs develops in the presence of atelectasis, regardless of the etiology. In massive atelectasis there may be frequent reexpansion of the atelectatic alveoli. This cannot occur in fibroid tuberculosis as here the alveoli are closed by the growth of fibrous tissue. A fibrotic lung with permanently obliterated alveoli is not an atelectatic lung. In atelectasis there is atrophy from inactivity of the lung parenchyma, followed in long-standing cases by hyperplasia of the connective tissue. Atelectasis is no more a complication of fibroid tuberculosis than is compensatory emphysema. It develops slowly, never re-expands and is never fulminating, an important point in differential diagnosis, since the physical signs and roentgen findings are very similar to those in massive atelectasis. The author details the roentgen appearances of the atelectatic lung with the possible diagnostic errors. In general, the physical signs of massive atelectasis are not sufficiently characteristic to differentiate it from a fibrosed lung. For such differentiation, the previous history, course, onset and serial roentgenograms may be of great help. Reports of 3 illustrative cases emphasize the author's contention that atelectasis cannot always be explained as due to obstruction of a bronchus by secretion, but is caused by many other factors.—*W. R. Brooksher.*

Schaefer, A., and Wurm, H. Lymphogranulom der Lungen mit Kavernenbildung. (Lymphogranuloma of the lung with cavity formation.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 254-262.

The authors present from a roentgenologic and pathologic point of view a rare case of cavity formation in mediastinal lymphogranuloma. Theoretical causes of the cavitation are discussed.—*E. T. Leddy.*

Bagnaresi, Giacomo. La tubercolosi del lobo dell'azigos. (Tuberculosis of the azygos lobe.) *Arch. di radiol.*, 1933, *9*, 697–708.

Two cases of tuberculosis of the azygos lobe are described and illustrated with roentgenograms. There were roentgen signs of pleurisy of the incisure and veiling of the lobe. Very few cases of tuberculosis of the azygos lobe have been described and the greatest care must be exercised in interpreting the roentgenograms as it is very difficult to differentiate it from other conditions which may occur even in lungs that do not have any azygos lobe, such as glands of the azygos vein, right paratracheal and innominate glands, which may herniate outward and give an opacity at the site of the azygos lobe. Along with the adenopathy there may be a spot of paranglandular mediastinal pleurisy which may produce the picture

of inflammation of the azygos lobe with thickening of the external margin simulating an incisure of the azygos lobe.—*Audrey G. Morgan.*

ABDOMEN

Perona Pietro. Contributo allo studio radiologico delle deformazioni pericolecistitiche. (Roentgen study of malformations from pericholecystitis.) *Arch. di radiol.*, 1932, *8*, 719–765.

The author reviews the morphology and function of the gallbladder and discusses his method of studying its function. He uses milk rather than Bronner's egg yolk medium as a stimulus to contraction. He describes in detail and illustrates with roentgenograms the malformations of the gallbladder that take place in pericholecystitis with adhesions to the duodenum or colon. There may also be congenital malformations with partial or total constriction of the gallbladder. Perivisceritis from appendicit is is one of the frequent causes of distortion of the gallbladder. These malformations generally appear only in the phase of emptying of the gallbladder and not on an ordinary cholecystographic examination. This functional test should also be used in calculous cholecystitis, as otherwise it is often difficult to differentiate between adhesions from cholecystitis and the profound involvement of the mucosa of the gallbladder manifested in strawberry gallbladder.

In pericholecystitis there may be decreased density of the shadow, indistinct margins and slight and delayed response to the alimentary stimulus from adhesions and not from impairment of the contractile capacity of the gallbladder itself. Therefore examination of the gallbladder should always be associated with a general examination of the digestive tract in which direct signs will give more information in regard to a possible perivisceritis.—*Audrey G. Morgan.*

Santoro, Mario. Calcificazioni del fegato di difficile interpretazione. (Difficult diagnosis of calcifications of the liver.) *Arch. di radiol.*, 1932, *8*, 281–289.

A case is described in a man of thirty-five who for years had had a vague feeling of weight and pain in the right hypochondrium. Some years before he had had a severe enterocolitis. On admission he had fever of the septic type with pain in the right upper quadrant of the abdomen. Examination of the feces showed amebae for which he was treated and recovered except that he still had vague pain in the right flank; no fever or icterus. Roentgen examination showed two dense irregular shadows in the right lobe of the liver. The liver was not enlarged. Excluding calcified echinococcus, as the picture was not typical, calcified tubercles, as there was no history or evidence of tuberculosis, and intrahepatic stones, as the general condition was not serious enough, the author concludes from the history of amebic dysentery and the frequency of abscesses in that disease, the type of fever and the localization of the shadows in the right lobe that they were calcified amebic abscesses.—*Audrey G. Morgan.*

Vajano, D. L'epatolienografia col thorotrast. (Roentgen demonstration of the liver and spleen with thorotrast.) *Arch. di radiol.*, 1933, *9*, 57–145.

This is an exhaustive study of the roentgen demonstration of the liver and spleen by means of intravenous injections of thorotrast in rabbits. It is illustrated with roentgenograms and photomicrographs of the histological findings and followed by tables giving the details of the results and by an extensive bibliography.

Not only can the spleen and liver be demonstrated in this way but the method is to a certain extent a functional test. The thorotrast is retained by the reticulo-endothelial cells of the organs and as a result gives an opaque image. In areas in which the reticulo-endothelial cells are injured there is no image. It is because of their greater content of reticuloendothelial tissue that the liver and spleen can be demonstrated with smaller doses of thorotrast than the other organs, though the bone marrow, placenta, lungs and kidneys can be demonstrated with sufficiently large doses. Except for the placenta, however, these doses do not lie within the limits of safety.

Doses of 0.5 to 1 c.c. per kilogram of weight are sufficient for demonstration of the liver and spleen and these doses are absolutely harmless. In fact, animals treated with doses six times as large and kept under observation for a year by means of serial histological examinations, periodical examinations of blood and urine and biological tests did not show anatomical or functional injuries of any of the organs.

The opacity of the spleen and liver begins within ten to twenty minutes after the injections; the spleen is distinctly visible within

three hours and the shadow reaches its maximum density within six hours, while that of the liver does not reach its maximum density until after twenty-four hours. A dose of 0.5 c.c. gives slight visibility and a dose of 3 or 4 c.c. a greater density than that of bone. If the entire amount is given at once it produces greater density than if it is given in fractional doses.

It was at first feared that the thorotrast might be harmful in cases in which there were serious lesions of the liver or spleen but this has not proved to be true. Periodical examinations of the urine do not show any injury of the kidneys while blood examination shows no change in the erythrocytes and only a moderate leucocytosis after the injections with no appreciable changes in the formula. It has not yet been definitely determined whether late injury may be caused by the radioactivity of the thorotrast. The author believes that this radioactivity is negligible but is carrying on further experiments to make sure of that point.—*Audrey G. Morgan.*

Colalè, Gaetano. La Bi-litiasi vescichetto renale come sindrome associata dell'addome destro. (Lithiasis of the gallbladder and kidney as an associated syndrome in the right abdomen. *Arch. di radiol.*, 1933, *9*, 316–334.

After discussing the anatomical and physiological relationships between the liver and kidney the author describes 2 cases in which there were stones in both the gallbladder and right kidney. Clinical diagnosis in such cases is extremely difficult as the symptoms of the two conditions are very confusing. Roentgen examination therefore becomes the only means of diagnosis and it is not easy. The gallbladder stones generally have a nucleus of cholesterin which does not give a shadow and a peripheral part of calcium which gives a characteristic picture. The kidney stones are uniform in density. Roentgenograms taken in the ventrodorsal and dorsoventral projections show whether the stones are anterior or posterior. A latero-lateral picture localizes the stones still better, showing the anterior position of the gallbladder stones and the posterior position of the kidney stones. Cholecystography with tetraiodide and pyelography with uroselectan are further aids in diagnosis. But the best method is telestereography which makes it possible to dissociate the stones of the gallbladder and those of the kidney. By the use of these various methods the correct diagnosis can generally be made.—*Audrey G. Morgan.*

Ricci, Carlo Carnevale. L'epatosplenografia nella cirrosi di Laennec. (Hepatosplenography in Laennec's cirrhosis.) *Arch. di radiol.*, 1933, *9*, 343–351.

The author discusses the technique of injection of thorotrast and then describes the picture of the liver and spleen as shown by this method of examination in Laennec's atrophic cirrhosis of the liver. In the beginning state the outline and structure of the liver are visible but in advanced cases the liver is invisible or barely visible. The spleen is much more opaque than normal and very much increased in size.—*Audrey G. Morgan.*

Comroe, Bernard I. Association of pituitary tumor and peptic ulcer. *Am. J. M. Sc.*, 1933, *186*, 568–573.

Cushing recently called attention to the relationship between lesions of the interbrain and peptic ulcer. During a year's time the author had the opportunity of studying 2 cases with pituitary tumor and in each of whom there was found in addition a peptic ulcer. Careful review of the literature failed to reveal a single reported case in which a diagnosis of pituitary tumor associated with peptic ulcer was made during life.

Inasmuch as lesions of the pituitary gland are always associated with disorders of the suprarenal cortex, and since recent experiments have shown that damage to the suprarenals will repeatedly produce intestinal ulcers (in animals), it is suggested that these 2 cases might supply the missing link in the chain of evidence supporting the alleged etiologic relationship between peptic ulcer and the endocrines.

Treatment of early cases of peptic ulcer by means of pituitrin subcutaneously seems worthy of trial.—*J. R. Andrews.*

Didiée, J.-J. Les types de formes anormales du trajet duodenal. (Types of abnormal forms of the duodenal tract.) *J. de radiol. et d'électrol.*, May, 1933, *17*, 265–274.

There are three types of abnormal forms of the duodenal tract which must be differentiated: (A) the type due to duodenal distortion on a congenital basis without any element of

ptosis; (B) the type resulting in the M-shaped duodenum which again is of congenital origin but has an element of associated ptosis, and finally (C) the type due to infraversion of the duodenum which is a particular form of ptosis without developmental disturbance. All three types may become complicated by secondary elements, resulting in functional disorders, but even then their essential characters will remain sufficiently clear to make a roentgen diagnosis possible.—*T. Leucutia.*

Robinson, W. R. Extra-bulbar or duodenal ulcer. *South. M. J.*, Sept., 1934, *27*, 759–763.

Less than one-tenth of postpyloric ulcers are situated in the duodenum proper, or that segment which begins with the initial plica circularis and terminates with the duodenojejunal flexure at the ligament of Treitz. The etiology, pathology, clinical symptoms and roentgen signs of this strangely neglected subject, based upon a study of 10 cases proved by operation, are discussed.

Theoretically, stasis may have a prominent rôle in the production of this type of ulcer. The pathological picture simulates that found in both gastric and cap ulcers, apparently depending upon the segment of the duodenum in which the ulcer is situated.

True duodenal ulcer is characterized by a protean symptomatology, and the roentgen examination is the most certain method of establishing the diagnosis. Although under normal conditions the duodenum does not lend itself very readily to roentgen examination because of the rapid passage of the bariumized meal, it is fortunate that delayed motility with stasis and distention facilitates the examination for suspected lesions. When the barium filling is not satisfactory, artificial dilatation by the Einhorn tube may be practiced.

In the pars superior the direct signs are a constant crater or niche on the inner aspect of the ring, or niche with accessory pocket on the anterior surface of the greater curvature, accompanied by marked distortion and narrowing of the duodenal segment and proximal dilatation. In the pars descendens the usual finding is a constant peripheral filling defect which may be associated with an incisura on the opposite curvature. In uncomplicated duodenal ulcer there is never any displacement or angulation present and if these are visualized, expansive lesions of the head of the pancreas or chronic pericholecystitis should be suspected. A localized dilatation with a central rarefaction of the barium shadow noted at times in the descending duodenum is not characteristic of ulcer, but suggests a tumefaction of the head of the pancreas. Ulcer craters, especially on the lesser curvature, must be differentiated from diverticula and filled Vaterian pouches. The indirect signs are both gastric and duodenal, frequently the same as those in ulcer of the cap: gastric hypertonus, hyperperistalsis and hypermotility. Localized tenderness is not constant. With adjacent ulcer the cap is diminutive or spastic. The characteristic duodenal stasis may be enhanced by reverse peristalsis. Gastric residue is commonly present and this finding in a stomach of regular contour, associated with hyperperistalsis, a normal cap, and normal cholecystograms, is almost diagnostic of ulcer of extra-bulbar position.—*W. R. Brooksher.*

Mondor, H., Gauthier-Villars, Paulette, and Sicard, A. Sarcome du pancréas. (Sarcoma of the pancreas.) *Presse méd.*, July 29, 1933, *41*, 1201–1205.

Sarcoma of the pancreas is a very rare disease and exceedingly difficult to diagnose. Following the observation of a case of their own, the authors reviewed the literature and were able to collect only 18 cases described. In the present article the lesion as such is discussed in detail from all angles on the basis of these cases, which are then very briefly abstracted. The following points are of interest: Half of the cases are less than fifty years of age, the site of the tumor being in those registered five times at the level of the head, five times in the tail and twice invading the entire pancreas. The macroscopic appearance is nearly always the same—the tumor appears smooth, regular, often fluctuating and giving the impression of a cyst. It is only rarely that it appears nodular and hard. The cystic appearance must be attributed to the action of the pancreatic ferments. The microscopic appearance likewise varies little, most of the tumors described having been of the spindle cell type. The clinical symptomatology is characterized by signs which do not differ from those of a pancreatic cyst, especially since in most instances the sarcoma constitutes the degeneration of a cyst. Perhaps the more marked pain, the more rapid increase in volume of the tumor, the presence of ascites and

the marked loss of weight may direct the attention toward the suspicion of a sarcoma. The diagnosis is based chiefly on the roentgen appearance, although here, too, the signs of a pancreatic cyst will entirely dominate the picture. If the tumor is localized to the head of the pancreas, an enlargement of the duodenal frame, modifications from the site of the duodenal bulb, absence of the mucosal fold markings, a diminution of peristalsis with gastric residue, and deformities of the stomach will constitute the most important signs observed. If, however, the tumor is localized to the tail of the pancreas the deformities of the stomach and colon, consisting chiefly of displacement or pressure effect, will appear more in the foreground. The authors insist that roentgenograms in profile always be made since they may furnish valuable information, especially in case of gastric or colonic displacement. In spite of this, however, it would be exceedingly daring to make a roentgen diagnosis of pancreatic sarcoma. By associating the clinical characters with the roentgen signs one may state at best that a sarcoma is suspected but it will remain for the exploratory laparotomy to furnish definite proof.

From the point of view of treatment, total extirpation is recommended, although it must be borne in mind that the prognosis is extremely grave. In only one of the cases was there given postoperative radiation therapy but since the seances were poorly supported this was discontinued.—*T. Leucutia.*

Ronneaux, Georges. Diverticules intra-spléniques d'origine gastrique. (Intrasplenic diverticula of gastric origin.) *Bull. et mém. Soc. de radiol. méd. de France*, April, 1933, *21*, 353–357.

Intrasplenic diverticular images of gastric origin are exceptionally rare. In reviewing the French literature for the past twenty-five years the author was not able to find one single case reported. He therefore believes that the 2 cases which he has personally observed will have a certain interest.

The diverticular images of the stomach are, as a rule, the result of extrinsic ulcers which have perforated through the stomach into the neighboring organs, there being adhesions present. The starting point is generally the lesser curvature, and the perforation is either towards the left lobe of the liver or towards the pancreas. If then there is present an enlargement of the spleen towards the stomach the ulcer may perforate into this organ. The author had the opportunity to present such a case at the meeting of the French Society of Electrotherapy and Radiology in January, 1923. The diverticula appeared in the form of a hook, originating from the greater curvature of the stomach and apparently an overlapping of the shadow of the spleen. At operation a penetrating ulcer was found invading the slightly enlarged spleen. In the second case, which the author presents at this time, the track of the diverticulum was a little more complicated, attaining a length of 25 cm., and extending away out into the shadow of the spleen. It is probable that in this case the ulcer formed a regular fistulous track which gradually enlarged due to penetration of food particles into the fistula. Unfortunately, an operation was refused so that no anatomic control could be obtained.—*T. Leucutia.*

Gauss, Harry, Singerman, I., and Black, Louisa T. The differential diagnosis of intestinal tuberculosis. *Am. Rev. Tuberc.*, Nov., 1933, *28*, 684–698.

The present observations are based upon an analysis of the histories, physical examinations, laboratory findings and roentgenological evidence in 125 cases of intestinal tuberculosis. While there is no pathognomonic sign of intestinal tuberculosis, the diagnosis may be suspected by the failure of any patient to make satisfactory progress when the pulmonary lesion is quiescent or improving. The common symptoms are: diarrhea, abdominal pain, abdominal tenderness, abdominal rigidity and cramps after eating. Certain digestive and constitutional signs and symptoms may be associated.

The roentgen ray is the most important single agent in establishing the diagnosis, presenting the following evidences: failure of the right side of the colon to retain the barium meal the normal period of time; the presence of spastic filling defects in the cecum and ascending colon; complete or nearly complete emptying of the colon within twenty-four hours. In the small intestine there likewise results hypermotility, a hypermotility difficult of detection unless certain complications result, which paradoxically enough produce the opposite effect in the emptying time of the small

bowel. Consequently, ileal stasis at nine hours is suggestive of ulceration of the small bowel or of the ileocecal junction. By the same reflex mechanism, sufficient spasm of the small intestine will result in gastric retention. These roentgen evidences indicate ulceration, and when they occur in a patient having the symptoms mentioned and the patient is known to have pulmonary tuberculosis, then a direct diagnosis of intestinal tuberculosis may be made.

The differential diagnosis must be made from those pathological states which give rise to hypermotility or ulceration of the intestinal tract and are fully discussed by the authors under the headings: protozoal and bacterial infections; disorder in function, position or configuration of the colon; digestive, nutritional, endocrine and rectal disorders; blood dyscrasias; cardiorenal disease; industrial poisoning, appendicitis and surgical complications.—*W. R. Brooksher.*

Perona, Pietro. Studio seriografico della regione ileocecale e del fenomeno dello Stierlin. (Study of the ileocecal region and of Stierlin's phenomenon by means of serial roentgenograms.) *Arch. di radiol.*, 1933, *9*, 173–204.

The author discusses in detail the peristaltic movements of the terminal part of the ileum before and during the passage of opaque paste into the cecum and ascending colon. He gives a number of series of roentgenograms taken at intervals varying from seven to sixty seconds with the patients standing and lying down illustrating the various phases of this movement. Normally the cecum fills first and then the ascending colon, the paste collecting first above the ileocecal valve and then being emptied into the cecum in a manner similar to that of the emptying of the pylorus into the duodenum.

Sometimes, however, Stierlin's phenomenon is observed—that is, the ascending colon fills without any intervening filling of the cecum. Stierlin thought that this was due to exaggerated rapidity of the passage of the paste through the cecum but the author thinks this is not necessarily true. Evidently it is due to different causes which disturb the function of the ileocecal segment of the intestine. Partial or complete Stierlin's phenomenon may be seen not only in cases of pericecal adhesions or in abscesses secondary to appendicitis but also in spasm of the ileocecal valve. The function of the valve is of great importance in the production of the phenomenon and a study of it is of value particularly in cases in which the appendix is invisible and the indirect symptoms have to be studied. Serial roentgenograms should be taken fixing every step of the filling of the large intestine in an effort to determine the factors which cause the anomalous filling.—*Audrey G. Morgan.*

Hirsh, Joseph E., and Morton, B. F. Visualization of the liver and spleen as a diagnostic aid in abdominal complications. *South. M. J.*, Aug., 1934, *27*, 683–689.

The authors discuss use, technique, reaction, distribution, animal experimentation, elimination and radioactivity of thorium dioxide sol as used for visualization of the liver and spleen. It is considered indicated as a diagnostic aid: (1) to determine the nature of a liver disease (abscess, cyst, syphilis, cirrhosis, primary or secondary tumor or amyloidosis), of which the greatest value is probably in ascertaining the presence of metastatic tumor in the liver; (2) to determine if a given upper abdominal mass is liver or spleen; (3) to differentiate intrahepatic disease from common bile duct obstruction in chronic jaundice; (4) to ascertain the position of the diaphragm when it is difficult to decide whether a lesion is above or below it; (5) to follow the progress of hepatic or splenic disease by means of serial roentgenograms, and (7) to use the agent therapeutically in hepatic malignancy. The authors have experienced no contraindications to its use. Routine employment is not advised at this time pending the accumulation of experience because of the potential danger of radioactivity.—*W. R. Brooksher.*

Schaefer, Walter. Zur Physiologie und Pathologie der Gallenblase in Schwangerschaft, Geburt und Wochenbett, unter besonderer Berücksichtigung der Steinenstehung in dieser Periode. (The physiology and pathology of the bile passages in pregnancy, during delivery and in the puerperium, with special reference to the occurrence of stone formation.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 42–59.

In pregnancy the functions of the gallbladder change just as the functions of other organs do, for example, the ureter. During pregnancy there is a stasis of bile which is caused by an al-

tered function stimulus of the vagus nerve. The pregnant uterus has no mechanical effect on the flow of bile. Diaphragmatic breathing is only slightly limited in the later months of pregnancy so the more limited excursions of the diaphragm play no important rôle in the emptying of the gallbladder.—*E. T. Leddy.*

HELD, A. Der Billroth I nach v. Haberers Technik in Röntgenbild. (The roentgenologic appearance of the Billroth I operation done according to von Haberer's technique.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 77–82.

As a result of the suture of the shortened stomach to the duodenum there is a marked change in the shape and motility of the stomach on roentgen examination. Later on, these changes undergo revision toward the normal and there results the formation of a new pyloric bulb which, with the functioning of the anastomotic ring, causes the stomach to empty. These are accompanied by changes in the mucous membrane of the stomach and duodenum. Pathologic deviations from this "normal type" show as swelling and thickening of the mucosa usually from mechanical causes, particularly if the stomach lies vertically.—*E. T. Leddy.*

WILLI, H. Die angeborene Pylorusstenose des Säuglings im Röntgenbild. (The roentgen study of congenital pyloric stenosis in infants.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 188–198.

The author reports a study of 38 infants with this lesion. He feels that the size of the stomach is absolutely and relatively related to the size of the abdomen. In the first four weeks the stomach is small or of normal size. In cases of long-continued pyloric stenosis the stomach is often large and atonic. The degree of enlargement of the stomach does mot parallel the severity of the disease, and the enlargement may vary in the same infant and depends on the irritability of the stomach wall. Often in pyloric stenosis there is a key-shaped dilatation of the prepyloric region. The axis of the stomach is generally oblique. Thickening of the stomach wall has been observed in 67 per cent of the cases and is most common in the more chronic cases. Deep peristalsis is a particularly characteristic finding and is absent only where there is great dilatation of an atonic stomach. The pathognomonic "syndrome de lutte" (Barret and Chauffour) was observed repeatedly, particularly in the younger patients but frequently was not observed in chronic cases. There is always delay in emptying the stomach. If there is a retention for six hours or more operation is absolutely indicated only if the stomach is tonic. Willi feels that roentgen examination not only is a practical and complete confirmation of the diagnosis but it gives a clear idea of the progress of the disease and may play a great rôle in determining treatment or the indications for operation.—*E. T. Leddy.*

TESCHENDORF, H. J. Röntgendiagnostik des Ulcus praepyloricum. (Roentgen diagnosis of prepyloric ulcer.) *Forschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 152–158.

Diagnosis of this lesion is made definite by the demonstration of an ulcer niche. Demonstration of the mucosal folds is another important diagnostic sign. Other signs may occur but they are not found exclusively in prepyloric ulcer. It is possible in some cases to distinguish benign from malignant ulcer but operation should be advised in doubtful cases. Sometimes it is possible to diagnose syphilitic or tuberculous disease of the stomach which may resemble ulcer on the basis of the roentgenologic appearance only.—*E. T. Leddy.*

GUTMANN, RENÉ A. Les caractères cancéreux des niches gastriques. (The cancerous characters of the gastric niches.) *Bull. et mém. Soc. de radiol. méd. de France*, Nov., 1933, *21*, 705–711.

Carcinoma of the stomach presents three more or less typical roentgen forms: (1) the fungation which results in a lacunar image; (2) the infiltration which produces a diffuse invasion of the gastric walls, and finally (3) the niche which is more or less typical. The present article deals only with this last aspect.

It may be said that the ulcerating form of cancer produces two different types of niches, the so-called plateau niche and the classical niche of an ulcer. The plateau niche, as its name indicates, consists in a rather long plateau-like formation of the lesser curvature which rises a little above the gastric line and has overhanging borders. It represents the roentgen section of a malignant ulcus rodens surrounded by a circular and slightly elevated border. Sometimes the border appears as a clear zone giving rise to the so-called soup-bowl-

like niche (meniscus sign). The classical ulcer niche is often exceedingly difficult to differentiate from a true ulcer. In this respect the author considers the following signs of importance: Favorable signs are, the onset at a young age, spells of limited duration followed by long quiescence the size of the niche being proportional to the duration of the lesion, regularity of the niche, disappearance of the niche between the painful spells, disappearance of the niche after gastroenterostomy. Unfavorable signs: Onset at a relatively advanced age, long duration (several months) the patient suffering continuously, non-proportionality in respect to the duration of the disease (the niche being too large for its duration), irregular appearance despite a relatively short history, persistence and, a fortiori, augmentation with gastroenterostomy.—*T. Leucutia.*

Angle, Lewis W. Ruptured gastric abscess with gastric carcinoma. *J. Kansas M. Soc.*, Dec., 1934, *25*, 468–469.

Report is made of a case of gastric carcinoma associated with an abscess of the stomach wall which had ruptured into the peritoneal cavity. The roentgen examination showed a typical gastric fibrosis. At autopsy, the wall of the stomach was intact without perforation, the perforation being in an independent part of the abscess wall. There was no elevation of temperature or leucocytosis.—*W. R. Brooksher.*

Gutzeit, Kurt, and Kuhlmann. Zur Röntgendiagnose der Gastroenteritis. (The roentgen diagnosis of gastroenteritis.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 141–151.

Gastritis and enteritis are usually associated and it is better to regard them as one condition. The roentgen diagnosis of gastritis is unsatisfactory and that of enteritis is seldom made. In gastroenteritis there are changes in tonus motility, secretion and resorption which facilitate the diagnosis. There are apparent sinuses in the stomach shadow, duodenal atony and accelerated or delayed opening of the pylorus and partial delay in the upper jejunum. There is usually a rapid passage of the meal through the ileum and so an early filling of the colon. There then follows delayed emptying of the colon. There is usually an abnormally liquid filling of the small bowel and proximal colon. This abnormal secretion of the bowel is accompanied by gas so that mirror-like appearances arise. In the absence of gas the increased secretion can be detected by ripple formations in the ileum and by a finely granular appearance of the wall of the colon. Changes in resorption are related closely to the increased motility of the small intestine. This increase of resorption in gastroenteritis may be observed by the passage of an iodipin emulsion. Practically all these signs occur in other lesions and may not all be present in this condition. The authors feel that a diagnosis of gastroenteritis is warranted only when all occur simultaneously in the same patient.—*E. T. Leddy.*

Muzii, Mario. Compressioni e dislocazioni dell'apparato digerente in alcune affezioni abdominali. (Compressions and dislocations of the digestive organs in some abdominal diseases.) *Arch. di radiol.*, 1933, *9*, 643–681.

Twenty-four cases are described and illustrated with roentgenograms. They show displacement and compression of the stomach and intestines by various intra-abdominal diseases, such as echinococcus cysts, enlargements and tumors of the spleen and liver, etc. Compressions and dislocations below the hepatic flexure of the colon are almost always caused by enlargement of the liver, those of the splenic flexure are due to pathological conditions in the spleen. It is sometimes difficult, however, to make a diagnosis of the cause as similar compressions and dislocations may be caused by pathological conditions of different organs. The masses causing the displacement must be studied carefully with reference to whether they are movable or fixed, whether they move with respiration and change of position of the patient and whether when they are moved passively they move the stomach or colon. Palpation with the trunk erect and turning the patient to right and left, and oblique and lateral roentgenograms are valuable in discovering some compressions of the lesser curvature of the stomach. Screen examination while graduated pressure is being made on the anterior wall of the stomach is valuable in establishing the cause of compression of the stomach. In some cases ascending or descending pyelography was found a valuable supplement to examination of the digestive tract. Pneumoperitoneum was used in a few cases.

The author believes that the publication of

such cases with roentgenograms will help to establish typical pictures for many such compressions and displacements. —*Audrey G. Morgan.*

GYNECOLOGY AND OBSTETRICS

Guthmann, Heinrich, and Stühler, Fritz. Die röntgenologische Feinstrukturdarstellung der Gebärmutterhöhle. (Roentgen demonstration of the fine structure of the uterine cavity.) *Fortschr. a. d. geb. d. Röntgenstrahlen*, 1933, *47*, 123–141.

The authors have demonstrated the fine structure of the uterine cavity by means of a new contrast medium and a new hollow sound used to introduce it into the uterus. The roentgenograms are taken by using a special localizer and a special film holder which is introduced into the rectum. Some of the findings are illustrated by reproductions of roentgenograms. The method is harmless and applicable to outpatients, and is capable of great application in the study of uterine lesions.—*E. T. Leddy.*

Cramarossa, Vito. Sulle diagnosi precoce di gravidanza con i raggi X. (Early diagnosis of pregnancy with roentgen rays.) *Arch. di radiol.*, 1933, *9*, 777–790.

A very early diagnosis of pregnancy by means of roentgen rays is not possible. Embryological studies have shown that the first centers of ossification appear at the end of thirty days. These however are so slight at first that they do not give roentgen images. By about the end of the tenth week a roentgen diagnosis can be made with careful technique and skilled interpretation of the roentgenograms. This, however, is of value for often a definite clinical diagnosis cannot be made until the twenty-second week.

The best position for making a roentgen diagnosis is the dorsal position with a bag of sand beneath the patient's kidneys and with the tube fixed in such a way that the normal ray coincides with the longitudinal axis of the uterus.

Roentgen diagnosis is of great value in demonstrating twin pregnancy, malformations of the fetus, abnormal positions and presentations and death of the fetus in the uterus.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

Payne, A. E. Three cases of Addison's disease radiographically confirmed. *Brit. J. Radiol.*, Dec., 1933, *6*, 747–750.

Report is made of 3 cases of Addison's disease, all tuberculous, which terminated fatally, and in which shadows roentgenographically demonstrated during life were found to correspond to areas of calcification noted at necropsy.—*W. R. Brooksher.*

Porta, Remo. L'indagine radiologica dell'apparato urinario con la urografia per via discendente o da eliminazione. (Roentgen examination of the urinary tract by descending or excretory urography.) *Arch. di radiol.*, 1932, *8*, 231–272.

The author describes his technique for the method which is variously called descending, or intravenous or excretory urography. A number of cases of various diseases of the urinary tract examined in this way are described and iilustrated with roentgenograms.

He finds that in a general way early appearance of the shadow and its disappearance within thirty to forty minutes with distinct visibility indicates good kidney function, delayed appearance of the shadow and long persistence with slight contrast indicates insufficient kidney function, while the lack of any image of the kidney, pelvis and ureters indicates serious insufficiency of the kidney. But the lack of detailed information and the frequent discrepancy between the results of elimination urography and those of the usual tests for kidney function show that this method cannot be substituted for the simpler methods of testing function.

Another serious disadvantage of the new method is that sometimes it does not give an image even in cases in which other tests show that kidney function is normal. In spite of this, however, it is of great value on account of its simplicity and freedom from danger and from the fact that it can be used in cases in which ascending pyelography is impossible. It is particularly valuable in hydronephrosis and in anomalies of the kidneys and ureters and in bladder diseases. It is impossible to give definite rules for the choice between descending and ascending urography. That must be determined in each individual case based on the physician's skill and experience and his knowledge of the

indications and contraindications of the two methods.—*Audrey G. Morgan.*

Livermore, G. D. Trauma of the ureter. *South. M. J.*, Oct., 1934, *27*, 861–863.

The diagnosis of rupture or laceration of the ureter is facilitated by intravenous urography, the iodide escaping at the traumatized area to cast a shadow on the film. With the low blood pressure of profound shock, very little urine is excreted and therefore an insufficient amount will escape to cast the shadow. In such cases the method may be employed after the patient has rallied from the shock.—*W. R. Brooksher.*

Moore, T. D. A consideration of the ureter in serial pyelograms. *South. M. J.*, Oct., 1934, *27*, 825–832.

The author's modification of the Bucky diaphragm tray permitting the exposure of three pyelograms in rapid sequence has been employed in 319 instances, 94 per cent of which disclosed definite evidence of ureteral peristalsis. Usually not more than thirty or forty seconds elapsed in the making of the three exposures, but where it was desirable to determine the emptying time of the kidney, a second series of exposures was made five, ten, and fifteen minutes after the original injection. Serial pyelograms demonstrate marked variations in the caliber of the ureter from one exposure to another, showing that the single pyelogram may lead to erroneous conclusions, especially in the diagnosis of ureteral stricture.

In this series kinking of the ureter was noted in 83 patients; in 69 the kinking was transient; in 14 the kinks were constant. Transiency of the kinking was noted in both the upright and recumbent positions.

Points of narrowing in a single ureterogram can rarely be interpreted as evidence of stricture, because normal ureteral peristalsis is a cause of such constrictions in more than 90 per cent of such pyelograms. Urographic evidence of ureteral stricture in serial roentgenograms is characterized by a point of constant narrowing with constant dilatation above the site of the lesion. Series of pyelograms made immediately before and immediately after the passage of the bulb through the ureter revealed that the "hang" noted on withdrawal of the bulb was more often due to spasm than stricture.

Temporary relaxation of the ureter resembling atony or ureterectasis may occur and is differentiated by serial films from dilatation due to mechanical obstruction and the like where the dilatation is constant.—*W. R. Brooksher.*

Truchot, P. Cystographie au collothor. (Cystography with collothor.) *Bull. et mém. Soc. de radiol. méd. de France*, May, 1933, *21*, 423–426.

In cystography the author has more recently employed collothor, which is a thorium dioxide in colloidal suspension of 30 per cent concentration. The preparation has the property that it flocculates in media of which the pH is either alkaline or acid, a deposit forming on the surface of the mucosa. The procedure is as follows: Following emptying of the bladder, 60 to 10 c.c. of collothor is injected through a vesical sound and then the fluid is let flow slowly through the sound until the bladder is emptied. Then air is immediately injected in a quantity which is equal to that of the evacuated collothor. Following this, roentgenograms are made in various positions.

In the discussion which followed this presentation, Belot stressed the great value of this method but he insisted that certain precautions are necessary. Since the visualization of the bladder outline is based on deposit and flocculation on its surface of the injected collothor, chemical changes within the bladder may influence this flocculation in one way or another. Therefore a positive result may sometimes lead to false interpretation whereas a negative result does not permit one to draw any conclusions. He stated that three preparations are now on the market, umbrathor, diagnothorine, and collothor, of which the last is the best because it is very easily evacuated without leading to the production of gel.—*T. Leucutia.*

Ross, Norman. Radiographic diagnosis of prostatic enlargement. *Lancet*, Jan. 7, 1933, *1*, 14–16.

Diagnosis of prostatic enlargement by rectal palpation fails to reveal the so-called prostatic bar obstruction while the cystoscopic study has its disadvantages and contraindications. Aerocystography is a rational procedure, obviously of prime value if cystoscopy is unsuccessful. Where cystoscopy is possible, it is still a valuable asset, giving a definite and helpful picture, even superior when the size of a large prostate

cannot be gauged due to the proximity of the cystoscope lens to the gland.

The method is applicable in (1) vesical calculi, (2) neoplasms, (3) foreign bodies, (4) compression from without, as by uterine tumor and (5) vesical diverticula; all conditions, however, are diagnosed more satisfactorily by other and more simple means.

Technical requirements are a bladder completely empty and a well-cleared colon. A No. 5 French catheter, to the distal end of which is attached a 20 or 50 c.c. syringe, is passed into the bladder, the patient requested to relax as much as possible and to refrain from straining as the piston is gently pushed in. The patient is cautioned to give warning when the bladder is full or when a desire for urination is felt. The catheter is clamped by a forceps and air injection repeated until the bladder is full, or positive pressure of bladder contents is obtained. Satisfactory diagnostic roentgenograms require that no part of the vesical walls be in contact. With the precautions stated, there is no danger of bladder rupture. The patient's discomfort is not a great inconvenience as it is of but a few moments' duration. Exposures may be made in one or more projections.

Prostatic intravesical enlargement presents a conical projection at the base of the bladder, its edges continuous with the vesical margin, a distinctive finding. A smooth upper border indicates a benign enlargement; an irregular border or limited enlargement suggests a malignant condition. Prostatic bar obstruction is to be suspected if the vesical symptoms are those of hypertrophied prostate but no definite conical enlargement is observed on the roentgenogram. A large fibrous bar may cast a well-marked shadow at the base with a straight horizontal upper margin, lying $\frac{1}{4}$ to $\frac{1}{2}$ inch above the lower margin. Diverticula are readily shown and may be confirmed by the use of the opaque medium in a cystogram. Following prostatectomy, tags of mucosa remaining, if sufficiently large, are clearly demonstrated. Illustrative roentgenograms accompany the article.—*W. R. Brooksher.*

SKELETAL SYSTEM

Guarini, Carlo. L'indagine radiologica dello scheletro degli sclerodermici. (Roentgen examination of the skeleton of patients with scleroderma.) *Arch. di radiol.*, 1933, *9*, 7–56.

Scleroderma is a disease in which there is thickening and hardening of the skin from hypertrophy of the connective tissue. It is not merely a skin disease, however, as examination shows changes in all the systems and organs. The author has made a roentgen study of 8 cases which are described and profusely illustrated with photographs and roentgenograms. In all of the cases there was a marked kyphoscoliosis, generally dorsal and in most a thinning or more or less total disappearance of the intervertebral discs and beginning fissures of the bodies of the vertebrae. In some cases there were small osteophytes of the vertebrae and more or less marked decalcification of the bodies. In 2 cases there was sacralization of the fifth lumbar which, however, the author thinks was congenital and not due to the scleroderma. The hands showed characteristic destruction of the phalanges due to osteoporosis and atrophy of the bones. In some cases the sella turcica was small and in one case it showed osteoporosis and osteolysis but the author does not believe there were characteristic changes in the sella caused by disease of the hypophysis. The long bones showed thinning of the cortex and more marked trabeculation than normal. There were no special changes in the joints. The lungs showed sclerosis and infiltration resembling those of pulmonary tuberculosis. These changes may be of the same type as those in the skin.

The changes are not pathognomonic of the disease but may be seen in other diseases also, such as Raynaud's disease, syphilis and arthritism, so they are not of great importance in diagnosing the disease, which can moreover be diagnosed from the skin lesions, but they may be of value in determining the true nature of the disease.—*Audrey G. Morgan.*

McMaster, Paul E., and King, Robert W. Tuberculosis of metatarsal bones. *J. Bone & Joint Surg.*, Jan., 1934, *16*, 202–204.

Tuberculosis of the long bones of the feet is seen quite infrequently in children and is even more rare in adults. The authors report the case of a sixty-year-old male who had had neither a previous history nor physical findings of tuberculosis. Another case of an eight-year-old colored boy with tuberculosis of the elbow and bilateral involvement of both first metatarsals is the only other case of metatarsal tuberculosis on record in the University of Chicago clinics.

In the case reported the roentgenogram showed destructive changes in the distal end of the first metatarsal bone which was first interpreted as an osteomyelitis rather than as a tuberculous process. Resection of the distal two-thirds of the first metatarsal gave the patient a useful and painless foot with the aid of a transverse and longitudinal arch support.

The pathological findings, namely, granulation tissue—tuberculous at the region of synovial reflection, but nonspecific in the subchondral areas—and destruction of peripheral cartilage, correspond to observations made of tuberculous arthritis in other joints.—*R. S. Bromer.*

Alajouanine, Th., and Mauric, G. L'évolution des arthropathies nerveuses et quelques-uns de leurs aspects particuliers topographiques et évolutifs. (Arthropathie des petites articulations des doigts ou des orteils, forme pseudophlegmoneuse des arthropathies.) (The evolution of the nervous arthropathies and a few of their particular topographic and evolutive aspects (arthropathy of the small articulations of the fingers and toes, pseudo-phlegmonous form of the arthropathies).) *Presse méd.*, Oct. 7, 1933, *41*, 1537–1542.

As the title indicates, this article deals with some rather rare aspects of arthropathies of the toes and fingers and with certain nervous diseases, chiefly tabes and syringomyelia.

I. Pre-arthropathic states. A pre-arthropathic state forms the initial process in all nervous arthropathies. The author includes two brief case reports to demonstrate this. He recognizes that these pre-arthropathic states are rarely recognized, but if a systematic roentgen study of the joints of all cases of tabes and syringomyelia is made they would be found more often. Pathologically, the pre-arthropathic states represent the first degree of a disorder of local calcium metabolism which in the more advanced cases leads to the marked osseous deformities around the joints.

II. Certain little known aspects of fully developed arthropathies. The author discusses certain unusual forms which are encountered in the joints of the foot and hand. (*a*) Joints of the foot. The classical description of the tabetic arthropathy of the foot is that given by Charcot and Féré, according to which the tabetic foot is characterized by: a deformity of the dorsum of the foot which is diffuse or localized to the metatarsus, a swelling of the internal border of the foot resulting in disappearance of the plantar arch and finally a modification of the axis of the foot, the metatarsus being deviated in relation to the tarsus. To these characters, P. Marie has added another sign, a shortening of the dorsum of the foot. The authors in examining their cases found that the lesions are not always as diffuse as described above. Thus Alajouanine with Bascourret and Mage called attention to a particular aspect, the so-called medio-tarsal tabetic arthropathy which is characterized by: deformity of the dorsum of the foot; thickening of the internal border of the foot and disappearance of the plantar arch, but there is neither a modification of the axis of the foot nor is there a shortening of the dorsum of the foot. Another unusual form was described by Alajouanine, Bascourret, Gopcevich, Ducas, Mage and Mauric which is called the metatarso-phalangeal or phalango-phalangeal arthropathy with dactylomegaly of the big toe. This lesion is characterized by the presence of a large toe with hypertrophy of the anterior portion of the internal border of the foot and arthropathy of the metatarso-phalangeal or phalango-phalangeal joints. In association there is always evidence of marked trophic disorders such as considerable deformity of the nail followed by a spontaneous falling out of the nail, mal perforant, more or less marked edema, etc. (*b*) Joints of the hand. It is especially in syringomyelia where the lesions are localized to the upper portion of the spinal cord that arthropathies of the fingers are observed. In a first morphologic type, which is now classical, the increase in volume of the fingers and even of the entire hand forms the chief characteristic. This type is called the cheiromegaly of the syringomyelia. A second type is that observed by the authors in a case of tabes which consists in a veritable spina ventosa involving the second and third phalangeal articulations. Finally, in a third form, the deformities may appear more profuse leading to the so-called deforming rheumatism of the fingers. Roentgen examination in such instances will reveal that nearly all articulations of the phalanges form the seat of marked deformities with lateralization of a portion of the axis of the fingers.

III. The clinical and roentgenographic evolution of nervous arthropathies. It is a fairly

well accepted conception now that nervous arthropathies evolve in spells with intervals of quiescence or even temporary regression between the spells. In this respect, one may encounter an entire series of acute or subacute morphological and sympathetic disorders so that the appearance during this phase merits the denomination of pseudo-phlegmonous aspect. The authors have observed it on the foot, big toe, and in the elbow, but it may occur in any other joint. Two case reports are included to demonstrate the clinical course of such a process. Roentgen examinations made regularly from year to year in these cases demonstrate the slow but gradual aggravation in both increase in size and extent of the above-mentioned signs. The sympathetic disorders then superimpose themselves during the acute and subacute stage on the osteo-articular lesions, finally giving place to the predominating effect of mechanical factors.—*T. Leucutia.*

Agati, Dino. Malacie post-traumatiche di ossa del carpo. (Post-traumatic malacia of the bones of the wrist.) *Arch. di radiol.*, 1933, *9*, 205–246.

Seven cases of malacia of the bones of the wrist are described and illustrated with roentgenograms—5 of the semilunar bone, 1 of the scaphoid and 1 of the trapezoid—in which a mistaken diagnosis was made from the clinical findings and the correct diagnosis was made only on roentgen examination.

The literature on the theories of the cause of these lesions is reviewed and the author comes to the conclusion that they are generally caused by trauma which either causes fracture or rupture of the vessels, according to Kienböck's theory, which seems to be confirmed by recent experiments of Sacerdote, or else causes vasomotor disturbances from lesions of the periarterial sympathetic nerves according to the theory of Leriche and Policard. An accurate knowledge of the cause of the lesions can only be obtained by minute and careful clinical and roentgen examination and it is of the greatest medicolegal importance in workmen's compensation suits.—*Audrey G. Morgan.*

Rogers, Mark H. A study of one hundred cases of subdeltoid bursitis. *J. Bone & Joint Surg.*, Jan., 1934, *16*, 145–150.

Rogers collected 100 cases of subdeltoid bursitis excluding all cases of distinct chronic infectious arthritis with involvement of many joints and also all cases of stiff shoulders resulting from fractures about the joint. The condition is not found in youth but in middle and old age. He had no cases in which the age was under thirty years. He divides the cases into three clinical groups: (1) the acute, fulminating type; (2) the chronic adhesive type, and (3) the traumatic type. The acute type comes on without any history of injury or infection and is extremely acute in onset, reaching its maximum intensity in three or four days. In this group the shadow of calcification is usually found in the roentgenogram. The acute fulminating type shows an appreciable number of patients between the ages of thirty and forty.

The so-called calcified areas shown by the roentgen ray in acute and sometimes in chronic cases of so-called bursitis are anatomically situated on the superior surface of the joint capsule and the supraspinatus tendon. They are not within the bursal sac, but the posterior wall of the bursa lies on the top of the deposit. Sufficient work has been done in the analysis of this substance to prove that it is essentially a calcium carbonate. In acute cases it is a thick, whitish substance, that can be handled like thick purulent material. The reason for this accumulation of a calcium salt in this area has not been satisfactorily explained.

The chronic adhesive type comes on slowly, and at the end of a month there is an absolute loss of abduction, but no acute pain unless the arm is moved. This presents an entirely different clinical picture from the acute group. The traumatic type follows a history of a fall or a twist of the arm.

Of 46 cases of the adhesive type, 18 were diabetic. Rogers is unable to explain this proportion of cases among diabetics except that it may possibly have something to do with the age of this group and that diabetes is apt to make tissues older, as is shown by the fact of early arteriosclerosis and changes in the blood vessels.

There is no evidence that there is an element of focal infection, as is so commonly thought. For this reason, Rogers states, the term periarthritis is misleading.—*R. S. Bromer.*

Elliot, George R. Chronic osteomyelitis presenting distinct tumor formation simulating clinically true osteogenic sarcoma. *J. Bone & Joint Surg.*, Jan., 1934, *16*, 137–144.

Elliott reports a case of an Italian, aged

forty-six, a carpenter, who was seized while at work, without any known injury, with a dull pain at the lower end of the right thigh. The swelling above the knee joint increased and became irregular in contour. Ten days later, the patient was admitted to the hospital. There was no history of typhoid fever and syphilis was denied. The Wassermann was negative; roentgen examination at this time was practically negative. Eight inches above the lower end of the patella, the left thigh was 3 inches greater in circumference than the right. There was marked tenderness of the lower part of the thigh, and pressure elicited pain which continued but at no time was paroxysmal.

Most of the 22 rules of procedure advocated by Bloodgood for the diagnosis and treatment of bone lesions were carefully observed. Roentgenograms were taken from time to time. At a somewhat later period the roentgenograms revealed a distinct soft shadow, and the clinical symptoms appeared more and more to suggest sarcoma. At this time a biopsy was made and a pathological report of a finding of a few pus cells was returned. Beyond this the findings were unsatisfactory. Amputation was decided upon and performed at the hip joint. Three and one-half years afterward, the patient was living and well.

The cross section of the lower end of the femur revealed a distinct tumor formation. In the roentgenogram, evidence of bone destruction could be seen. Outside the cortex a large mass of soft tissue, apparently semi-organized, could be seen. Histologically the tumor mass was composed largely of plasma cells, the presence of which spoke strongly for a rather subacute or chronic inflammatory process as its producing factor.

In his summary, Elliott states that this case may prove to be a real entity or at least, a very atypical form of a classical bone lesion. He quotes Ewing who reviewed the specimens and said that he considered it a most unusual case and that further, to his knowledge, had never been described. He could conceive of a finding such as this case, arising from a bone infection of a low grade and leading to abundant plasma cell reaction, the plasma cell formation finally predominating as the infection subsided and leading to a condition not unlike the case reported. To this might be given the name "osteomyelitic plasma-cell myeloma."—*R. S. Bromer.*

Gellman, Moses. Osteochondritis of the patella; including a case with multiple epiphyseal involvement. *J. Bone & Joint Surg.*, Jan., 1934, *16*, 95–104.

Gellman reports 2 cases of osteochondritis of the patella, the first, a patient with the simple primary type of osteochondritis, and the second, a case showing marked involvement of the patellae in combination with multiple lesions elsewhere, the tibial tubercles and ossa calcum.

In the first case, roentgenograms showed a small ragged patella with numerous areas of lessened density and incomplete ossification, and with a tendency to fragmentation at the lower pole. Two years and four months later there was almost complete restitution of the bony structure of the patella, the trabeculations were coarse and several spiculations were present about the periphery at various points. In the second patient, both patellae showed marked disorganization of their structure, with fragmentation, splitting, areas of lessened density, and incomplete ossification. There were also irregularities at the osteochondral borders at the lower end of each femur. Two years and four months after the first visit, the patellae were somewhat thickened and larger in both diameters and there was distinct cupping in the regions of the tibial tubercules.

Recently two types of osteochondritis have been described, primary and secondary, depending upon whether the primary or secondary center of ossification was involved. Since ossification of the patella commences at the age of five or six years, the primary type of osteochondritis is common at these ages when the center is rapidly growing. Rarely, the patella will develop secondary centers of growth at puberty. When they do appear and are involved in the osteochondritic process, secondary osteochondritis results. The patella is often subject to various developmental anomalies, having accessory centers of ossification, usually at the outer margin of the bone. Erroneous diagnoses of vertical fractures due to such centers must be avoided. Such defects are bilateral in two-thirds of all cases. Often the osteochondral line of the lower femoral epiphyses as well as the tibial tubercles are involved in the osteochondritic process since these two sites are within the vulnerable area of the strong pull of the quadriceps tendon.

Gellman quotes Mau who believes the

process is the result of an aseptic necrosis. Mau believes, too, that injury of the patellar vessels occurs at the points where the vessels are subjected to the powerful pressure and pulling effects from the attachments of the quadriceps tendon. Aseptic necroses follow these embolic manifestations and thus account for the alterations in the structure of the patella. It can thus be seen that, while the pull and pressure factors are active in all normal subjects, apparently circulatory defects, similar to those described by Mau, must also be assumed to be present in a given subject before these peculiar osteochondritic changes occur.—*R. S. Bromer.*

Mondor, H., and Sicard, A. Un cas d'ostéopsathyrose; maladie de Lobstein. (A case of osteopsathyrosis; Lobstein's disease.) *Presse méd.*, Nov. 18, 1933, *41*, 1856–1857.

The hundredth anniversary of Lobstein's book "Traité d'Anatomie pathologique" has given the authors the opportunity to consider the condition which in France is known under the name of Lobstein's disease. The original description of Lobstein is rather vague, he having distinguished two types of alterations of the bone, the softening (osteomalacia) and the fragility (osteopsathyrosis). During the course of time other authors have added further signs. Thus Poncet stressed the idiopathic character, von Ammon, Eddowes, and especially Spurway described the ocular signs, van den Hoewe and de Kleyn the auditory disorders and finally Bell and Apert have furnished the best descriptions in ensemble. One may say now that the disease is characterized essentially by a triad consisting of osseous fragility, blue sclerae and deafness.

The authors in this article describe in great detail a case which they have observed in a woman fifty years of age who during her life suffered nine fractures. The case was studied from all angles over a long period of time since it represents the above-said disease in a most typical manner. The histologic examination of the thyroid and parathyroids remained entirely negative. Likewise the histologic signs observed by Key—thinning of the corticalis, dilatation of the Haversian canals and irregularity in the deposition of the osseous lamellae—were not verified on the fragment of the tibia which was removed for biopsy. Finally, in contradistinction to the assertion of Haas, who stated that the newly formed callus is so resistant that no fracture can recur in the same place, the authors found that several of the fractures in their case reappeared in callous portions of formerly healed fractures.—*T. Leucutia.*

Sutro, Charles J., and Pomeranz, Maurice M. Geometrical analysis of scoliotic spines. *J. Bone & Joint Surg.*, Jan., 1934, *16*, 65–68.

Sutro and Pomeranz propose a method for the accurate determination of the curve of scoliotic spines, whereby the amount of compensation or decompensation of a scoliotic spine can be accurately measured by comparing the geometrical figures formed by lines drawn from the second to the ninth ribs on both sides. The normal outline of the chest is designated as a trapezoid and abnormal chests in scoliotics show geometrical variations from that outline. Correction of the scoliotic curve should tend to produce a geometrical outline of the chest, approximately of the trapezoid type.

Their technique is standardized. A Potter-Bucky diaphragm is used, fixed tube stand, and a target plate distance of 28 inches. The patients are examined roentgenographically in the standing position. In cases with a marked tilt of the pelvis, correction is attempted. The paper is illustrated with diagrams which fully explain the angles used, etc., to determine the degree of curvature and the amount of correction obtained.—*R. S. Bromer.*

ROENTGEN AND RADIUM THERAPY

Laborde, Simone. Les épithéliomas des paupières et leur traitement par le radium. (Epitheliomas of the eyelids and their treatment by radium.) *Presse méd.*, Oct. 7, 1933, *41*, 1548–1550.

The use of radiation therapy (with roentgen rays or radium) in the treatment of epitheliomas around the eye is often questioned because of the more or less serious alterations which are produced on the various membranes of the eyeball. Already the experimental investigations of Birsch Hirschfeld dating as far back as 1905 demonstrated that roentgen rays and radium in larger doses produced definite damage to the epithelium of the cornea and to the iris of rabbit eyes. Later investigations led to similar observations. The complications which one has to fear most are the superficial or interstitial keratitis leading to

more or less complete opacification and the late appearance of cataract due to the effect on the capsular epithelium of the lens. The after effect of irradiation may also lead to phenomena of ocular hypertension with resulting glaucoma.

In view of all these complications, it is of paramount importance that the therapeutic agent for epitheliomas around the eye be chosen in such a manner that no damage to the normal tissues should result. The author resorted to radium which was first used in the form of external applicators and lately entirely in the form of interstitial puncture which appears the safest. Needles containing 2 mg. radium element filtered by 0.5 mm. platinum are introduced within the carcinoma tissue and left in situ for a period of from three to seven days, depending on the size of the lesion. In this procedure the quantity of the radium utilized is a minimum one, often not more than 2 to 4 mg. The maximum of radiation is absorbed by the epitheliomatous tumors so that very little reaches the eyeball proper.

The number of cases of epitheliomas of the eyelids observed by the author is 84 out of a total of 676 cutaneous cancers, that is, a proportion of 12.4 per cent; 56 of these were treated by radium, a complete disappearance of the lesion being obtained in 50. The scar resulting from the healing was usually smooth and no or only a very minimum deformity of the eyelids was observed. The normal tissues of the eyeball continued to remain intact.— *T. Leucutia.*

Santoro, A. Problemi di radiumterapia dei cancri cutanei. (Problems in radium therapy of cancer of the skin.) *Arch. di radiol.*, 1932, *8*, 213–230.

Skin cancer is one of the most fruitful fields for the use of radium irradiation. One of the problems that must be met, however, is that of acquired radiosensitiveness or radiovaccination. If the tumor is not destroyed by the first irradiation it acquires a resistance to the rays that makes cure difficult or impossible. Therefore an effort should be made to cure the tumor by a single irradiation or a continuous series of irradiations. If this fails a second irradiation with a very large dose may be tried. But not more than three attempts should be made.

The treatment is generally applied by radium carriers fixed in apparatus of Columbia paste. The amount of radium used and the time of application vary depending on the nature of the tumor and the stage of its advancement. As in all tumors, early diagnosis is of the greatest importance. Details of dosage and filtration are given for the various forms of skin cancer—the spindle-cell, basal cell and metatypical carcinomas with their subvarieties, and also for gland metastases and various precancerous conditions such as nevi, Kaposi's xeroderma, Paget's disease and senile and presenile keratoses. Electrocoagulation may be used advantageously in association with radium treatment where large masses are to be destroyed.—*Audrey G. Morgan.*

Ullmann, H. J. Roentgenotherapy of superficial malignancies. *Calif. & Western Med.*, October, 1934, *41*, 230–332.

Radiation, properly used, offers by far to the largest proportion of all superficial malignancies a method of treatment resulting in as high, or higher, percentage of cures of all cases seen as any known procedure. In addition, with the exception of the very small early lesions, the scarring and deformity, the pain and discomfort are infinitely less. The author does not prefer roentgen rays to radium and calls attention to the fact that many supposedly incurable cases which receive palliative irradiation, are ultimately cured. The Martin technique of large cauterizing doses of unfiltered rays, 1,700 to 2,500 r for the first, followed by two more of 1,250 to 1,500 r each at forty-eight hour intervals is employed. These are measured in air for all areas approximately 4 cm. square or less, and on the skin or total skin dose for the larger lesions. Accurate and constant measurement is essential.—*W. R. Brooksher.*

Degrais, P., and Bellot, A. Les méfaits de l'attente dans le traitement des angiomes; avantages de la curiethérapie. (Disadvantages of delay in the treatment of angiomas; advantages of curie therapy.) *Presse méd.*, Nov. 18, 1933, *41*, 1848–1851.

In a comprehensive article which appeared in 1924 the authors dealt with the etiology and pathology of angiomas, described their various clinical forms and finally discussed the best method of treatment *in extenso*. In the present article they wish now to stress two additional points, both very important from the point of view of therapeutic results: (1) the onset and

(2) the evolution of angiomas. (1) Onset. One may say generally that angiomas already exist at birth. If the history indicates that the lesion appeared later in life it is most probably due to the fact that the time of onset was not correctly observed. (2) Evolution. From this standpoint the authors divide the numerous clinical types of angiomas into two general groups: (*a*) flat angiomas, which usually appear in their entire extent at birth, showing little change afterwards except perhaps in the fact that the color becomes darker, and (*b*) tuberous angiomas which only rarely appear at birth in their entire extent. An increase of volume is observed from the first weeks following birth and if the lesion is not treated this continues unabated.

In the second, longer part of the article, the authors discuss the various therapeutic methods, stressing the great advantage of curie therapy which must be undertaken as early as possible. The inconveniences of delay are (1) increase of volume which, as above stated, is nearly the rule in the tuberous angiomas; (2) ulceration resulting in scarification and deformities of the contour of the skin with poor cosmetic effect; (3) diminution of sensitivity, it being commonly known that an angioma is the most sensitive to all kinds of therapeutic agents the younger it is; (4) increase in the duration of treatment brought about chiefly by increase in the extent of the tuberous angiomas. On the basis of experience in more than 2,000 angiomas treated since 1906 the authors state that curie therapy in surface application forms the method of choice. This has the advantages: (1) that it is completely painless; (2) that it can be applied from birth; (3) that it can be used in any region; (4) that it gives as good results in the superficial as in the deep zones, and (5) that it leads to most satisfactory cosmetic results. It is emphasized, however, that the fractionated method with applicators of low strength must be used so as not to produce too much of a deep effect on the structures which are in the course of development.—*T. Leucutia.*

Cola, G. I metodi fisici nella cura delle nevralgie. (Physical methods in the treatment of neuralgia.) *Arch. di radiol.*, 1933, 9, 560–578.

The author discusses the various methods of physical therapy in neuralgia. He has used various methods including diathermia, electricity, ultraviolet rays and roentgen rays in 73 cases, 33 of the sciatic nerve, 16 of the trifacial, 11 of the brachial plexus, 9 of the intercostal nerves, 2 of the femoral and 2 of the occipital.

Roentgen therapy is the treatment of choice in trifacial neuralgia. He irradiates either the Gasserian ganglion or the point of exit of the affected branch. The treatment has little effect in stubborn cases in individuals of nervous or psychopathic constitution. The effects are marvelous in cases following acute infections, also in moderately severe cases of unknown etiology. Among 9 cases treated with roentgen therapy 5 were completely cured, 2 improved, 1 greatly and the other, a stubborn case, moderately, and 2 patients who had had the disease for twenty years were not improved at all. In cases limited to one branch he generally prefers diathermia.

In brachial neuralgia diathermia is generally to be preferred. Among the 11 cases treated, 5 were completely cured by 15 to 20 diathermia treatments, 2 by diathermia and ultraviolet rays and 1 by diathermia and roentgen rays. Among the other 3 cases 2 were moderately improved and 1 not helped at all.

In intercostal neuràlgia roentgen irradiation is the treatment of choice. All of the 9 cases treated were completely cured.

Diathermia is the preferable treatment in the majority of cases of sciatica. It should be given as soon as the acute stage is over with. In cases in which diathermia increases the pain or is not effective roentgen treatment should be used and recently the author is becoming more and more convinced of the value of combined diathermia and roentgen treatment followed by electrical treatment. Among his 33 cases 14 were cured by diathermia alone, 4 by combined diathermia and electrical treatment, 10 were cured and 2 improved by combined diathermia and roentgen treatment and 3 were not helped.

In roentgen therapy he uses rays of moderate hardness, spark gap 30 cm., filtration with copper and aluminum, rather small fractional doses (100 to 150 r). The roots and trunks of the nerves are irradiated. Two treatments are given per week and generally a total of 6 to 8. This series may be repeated if necessary after twenty to thirty days.

He discusses the different theories in regard

to the mechanism of action of the rays and thinks there is no doubt they have a local action by increasing the activity of the circulation and bringing about absorption of the infiltration. This does not account for all of the cases, however, and he thinks the rays probably also act by changing ion concentration. It is also possible that they act directly on the lipoids of the nerve tissue.—*Audrey G. Morgan.*

Bioglio, Mario. Contributo alla radiumterapia in alcune forme cliniche meno comuni. (Radium treatment in some unusual conditions.) *Arch. di radiol.*, 1933, *9*, 335–342.

The author describes a number of cases of leprosy and one of leishmaniosis treated in South America by radium therapy. In the leprosy cases platinum tubes were used with primary filtration of 0.5 mm. platinum and no secondary filtration. A single treatment was given with varying periods of time and amounts of radium varying from 5 to 60 milligrams. In the leishmaniosis superficial treatment was used without filtration except for some of the ulcers in which there was deeper infiltration where a filter of 0.5 mm. lead was used.

All the cases were cured quickly and there has been no recurrence in four years.—*Audrey G. Morgan.*

Zimmern, A., Chavany, J.-A., and Brunet, R. Résultats obtenu dans le traitement de la maladie de Basedow par l'irradiation de la région surrénale. (Results obtained in the treatment of Basedow's disease by irradiation of the suprarenal region.) *Bull. et mém. Soc. de radiol. méd. de France*, June, 1933, *21*, 454–459.

A year ago the authors presented a case of true Basedow's disease which was cured following radiation therapy of the suprarenal region. This cure has persisted since then. On the basis of this first observation, the authors treated several cases by the same method, the results being as follows: in 11 cases a complete cure was obtained, 5 cases are on their way to a cure, the treatment being still continued, and 3 cases in which the treatment was followed by amelioration did not complete the irradiation.

These results are interesting because they demonstrate the close association of the adrenals and sympathetic system in Basedow's disease. Several theories are advanced for the explanation of this association but the unusual feature of the results obtained is that the irradiation acted not only on the symptoms connected with the sympathetic system but also on the thyrotoxicosis which receded simultaneously. The studies will be continued.—*T. Leucutia.*

Delherm and Morel-Kahn. Note sur la radiothérapie dorso-lombaire dans le traitement de la maladie de Graves-Basedow. (Dorsolumbar radiotherapy in Graves-Basedow's disease.) *Bull. et mém. Soc. de radiol. méd. de France*, June, 1933, *21*, 459–463.

The authors report 9 cases of true Basedow's disease which were treated by irradiation of the dorsolumbar region according to the method described by Zimmern, Chavany and Brunet (see above abstract), that is, 400 r per seance on each side with 18 cm. spark gap, 5 mm. Al as filter, a series comprising 1,600 to 2,000 r administered within a few days. The results are not as favorable as those reported by Zimmern and his coworkers, but it must be stated that in many instances the treatment was not continued for a sufficient length of time. It is possible that the dorsolumbar paraspinal irradiation acts only in those cases of Basedow's disease in which the adrenals form the primary focus, whereas if the primary excitation is in the cervical sympathetic plexus an irradiation of the neck will prove the method of choice. It is assumed of course in both instances that the affection of the sympathetic system is the provoking cause of the Basedow's disease.—*T. Leucutia.*